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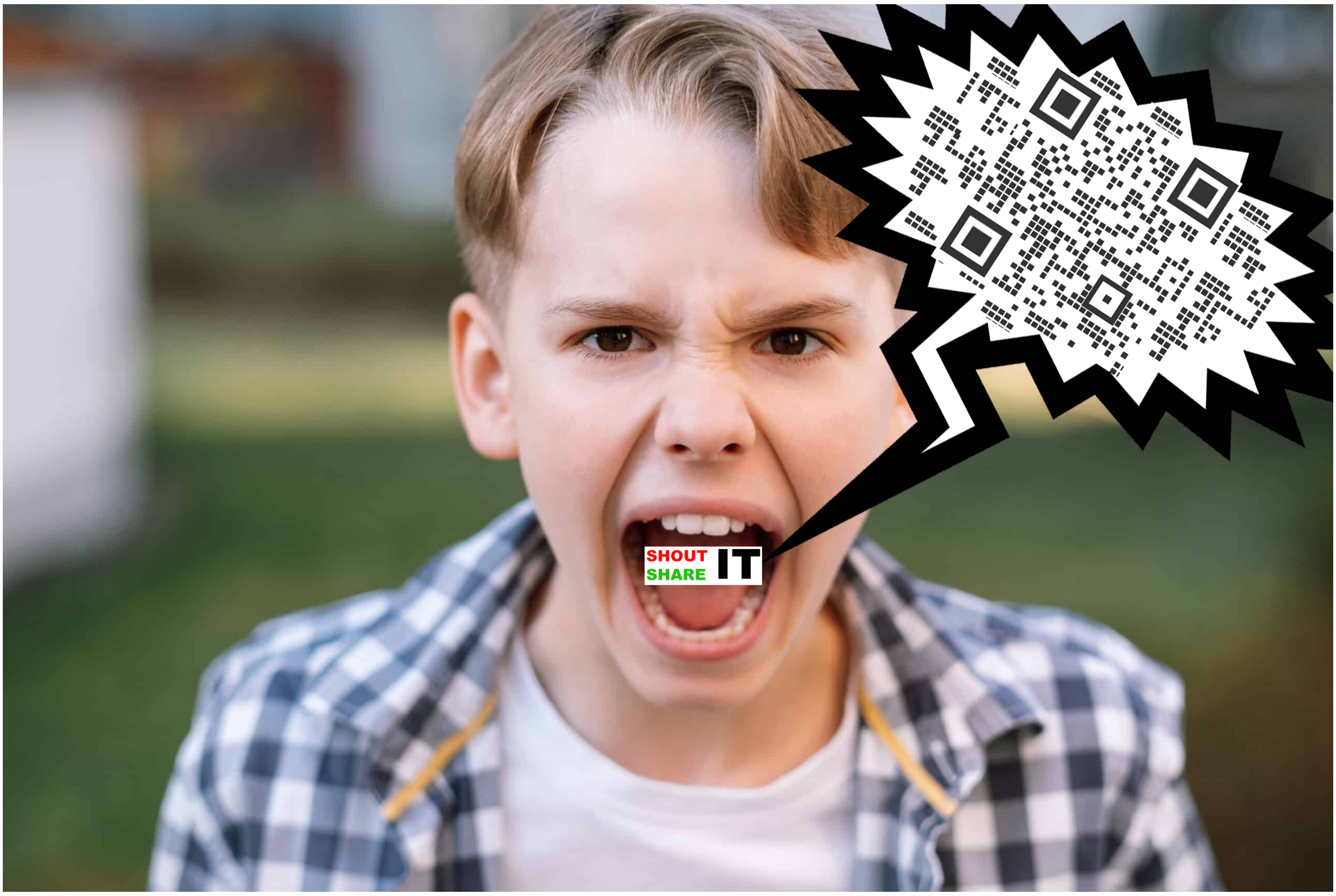
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ERRATA.

P. 146, line 11 from below, for Miyabe read Miyake.

P. 147, line 9, for BROOKS read BEECHER.

P. 229, line 8 from below, for relationship (twice) read relations.

P. 229, line 8 from below, for is read are.

P. 239, line 7, for Honkongense read Lankongense.

P. 327, line 8 from below, for *heucherae* read *Heucherae.*

P. 327, line 6 from below, for *lespedegae* read *Lespedezae.*

P. 327, line 21, for students of read students in.

P. 327, line 9 from below, for *haleniae* read *Haleniae.*

P. 327, line 9 from below, for Halway read Holway.

P. 328, line 11 from below, for chromatosphere read chromatophore.

P. 328, line 9 from below, for Ecocapaceæ read Ectocarpaceæ.

P. 328, footnote 6, for 1887 read 1897.

P. 406, line 10 from below, for Beta read *Betae.*

P. 411, line 9, for fine read five.

P. 412, line 4, for Torreyana read *Torreyana.*

P. 415, line 2, for 1875 read 1836–1875.

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VOLUME XXVII NUMBER 1

BOTANICAL GAZETTE

JANUARY 1899

ON THE VEGETATION OF TROPICAL AMERICA.[1]

EUG. WARMING.

TWICE I have been able to visit tropical America. The first time was about thirty years ago, when as a young student I stayed for over three years in Brazil, almost the whole time in Lagoa Santa, with the paleontologist, Dr. P. W. Lund. The second time was in the winter of 1891–2, when I traveled for some months in the Antilles and Venezuela. Having been requested to deliver an address at one of the general meetings of naturalists I have thought that perhaps it would be of interest to those present to hear some statements about the vegetation of tropical America, and some attempts to explain its deviation from our own northern one. Most likely these statements will in some degree correspond with the facts about other tropical countries, but as it is best to keep to what we are in some degree acquainted with, I must say that where in the following I am speaking of tropical facts, it is especially the American ones that I have in mind.

The interest of the northern botanist newly arrived in the tropics is immediately awakened by the variety of species, genera, and even families of which he has never seen living representatives. Of course this is not peculiar to the tropics, for into whatever non-tropical or even alpine region he goes, he will find a wide difference from the vegetation of his native country. But when he has viewed things somewhat closer, especially in the forests, it is the *multitude of species* and *the poverty of specimens* of every species that sets him wondering, and as these facts are characteristic of the tropical flora, I shall begin by speaking of them.

---

[1] An address before the Scandinavian Association of Naturalists, at the Copenhagen meeting.

Every one has heard of that multitude of species. When wandering through a forest, and looking upward into the foliage, one finds the most different forms of leaves showing their outlines against the bright sky. Trees and bushes of the most different species are to be seen everywhere, but one seldom finds more than a single individual of the same species. If in search of more than one specimen of a certain species, one will very often have to seek a long time; and of certain species of forest trees near Lagoa Santa I was able to find but a single individual.

To my knowledge there is no botanist who has illustrated this curious tropical richness of species by numbers. I am fortunate in being able to give some numbers that seem to be rather elucidative. Through the three years in which I lived in Lagoa Santa, I constantly made botanical excursions; but since, on an extreme estimate, only six or seven hours of the day were entirely at my disposal—and just those hours in which the heat was at its height—and since I had to take nearly all my excursions afoot, the ground investigated was only about 150 square kilometers in extent. On this insignificant territory I have gathered more than 2600 vascular plants, besides some hundred lower plants, but as I have not found absolutely all the species, especially not all those of the forest, I certainly may assume that the place contains at least 3000 species of higher plants.[2]

One will understand the meaning of this number if he examines an equal area in the fertile parts of the northern countries, which will be found to contain only about one fourth part of the aforesaid number. If we take the whole of Denmark with its 38,300 square kilometers, we find only half of the given number; and if we take Sweden and Norway, with an approximate area of

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[2] *Vide* my work "Lagoa Santa," in the Danish Videnskabernes Selskabs Skrifter VI. **6**:—. 1892.

772,900 square kilometers, we find not even two-thirds as many species. Yet these countries have both forest and meadow, heath and shore, rocks and moorland; in short a much more varied vegetation than the 150 square kilometers around Lagoa Santa, that are almost entirely covered with campos and forest.

I may give some other numbers; for example, the number of specimens of trees, small and large. The forests around Lagoa Santa seem especially to follow the watercourses. In every valley runs a brook, or a creek, or a river, on its way to Rio des Velhas. The forests form a border of variable breadth to these streams. They advance up the rather rugged terrain until the hills become too dry for them and the vegetation of the campos conquers them. Suddenly, then, the forests are succeeded by campos, that unbrokenly cover all the tops of the hills and all elevated ridges. The predominant feature of the country is the campos, or what the Spaniards would call savannas; flowery grassland that, where the red clay soil is deep and rather free of stones, also bears scattered trees, and has the likeness of a park or a garden with fruit trees; for the trees of the campos have not the straight and high trunks that are peculiar to the trees of the forests. On the contrary, they are like our fruit trees, low, with crooked stems and branches, and broad, open crowns, through which the sun's rays unhindered reach the grassy ground beneath. It must be noticed that where the campos are most vigorous the trees are able to form groups that have almost the aspect of groves or small forests.

The campos and the forest vegetation are two quite different formations, both in a biological and in a floristic way. The species of the forest are quite different from those of the campos, with the exception of a very few. Do we not find a second proof of the curious richness of species in the tropics in the fact that in the campos of Lagoa Santa not less than ninety species are to be found, and in the forest about four hundred? Of course the trees are growing intermixed. Several times I had an excellent opportunity for studying the composition of the forests. When a Brazilian farmer lays out a plantation, he cuts down a piece of forest at the beginning of the dry season, and the burning sun having for some months heated through and dried the mass of felled trees, bushes, creepers, herbs, and the crowd of epiphytes that lived in the forest, he burns up everything, and in the ground now fertilized with the ashes and afterward cleared and leveled, he sows and plants.

One can imagine the botanist's joy. Those trees, at whose crowns and flowers he had gazed so often without being able to reach them, lie now, by such a "Derrubada," outstretched at his feet. In six different cases I have estimated the proportionate numbers of the species and individuals, and I have found that among 50–250 trees there were 27–91 species; that is, every species was represented on the average by two or three individuals. To us of the north, accustomed to the uniform forests of beeches, spruces, firs, etc., there is something most strange and overwhelming in such a variety of forms.

As in the trees, so in the other parts of the vegetation, the herbs and shrubs. The same thing is also true in the animal kingdom. Wallace says that more than 700 species of butterflies live near Para, on the Amazon, while all Germany has but 150, and England only 64 species.

Now the question arises: What is the cause of this multitude of species in tropical nature? It seems obvious that these hundreds of trees, to speak only of them, living together in a forest of such small extent as this one near Lagoa Santa, must be similarly equipped in a physiological way, so that one species is not able to overcome and supplant another in the manner we know the beech, with us, is supplanting the oak. Every one of these tropical forest trees must shade as much, and at the same time be as well suited with the shade, as the others; that is, they are alike in fighting condition. In short, they must stand in quite the same relation to one another as the single individuals of the very same species; that is, just as the beech trees are interrelated. But how they have been able to reach this adaptation is a very difficult question, of which an explanation is at present an impossibility. Nevertheless, there is *one* condition that no doubt has played a conspicuous part in the process; I mean the history of evolution of tropical nature.

All characteristics of a vegetation may be classified into two groups of factors, *historical* and *physical*. All alterations that the climate, the ground, and the surface of a country are passing through from time to time must express themselves in the vegetable world up to this very day. Consequently this is the case with the inner highland of Brazil where Lagoa Santa is situated.

In the first place, Brazil is a primeval country, Geikie's map[3] showing us that even in paleozoic time, when the firstlings of life appeared on the earth, the highlands of Brazil and Guiana were raised above the sea level, while the other parts of the future South America were still in the keeping of the sea. In subsequent geological periods the area of land grew larger. The red clay that forms the surface of large parts of the soil is a decomposition product of the primitive rock. Also the lime rocks, that stick out through the clay here and there in Rio des Velhas valley, and in which P. W. Lund's celebrated caves with their fossil remains of extinct species of animals are found, are of a primeval limestone without vestiges of fossils.

Secondly, this highland has, so far as we know, been favored by the most excellent tropical climate. Though the ice on the highest of South American mountains is said to have been far more extensive formerly than now, no glacial period is known to have spread its life-killing mantle over the highland of Brazil. Then the vegetation developed itself undisturbed through geological periods. The species of plants have differentiated, fought out their conflicts, accommodated themselves to one another, and blended with one another. The vegetation has thus had plenty of time, and only when we take this fact into consideration shall we get nearer to an understanding of the present variety of species.

How widely different, for instance, are the facts in northern Europe! Here we have to do with a comparatively young vegetation. Geologically speaking, only a short time ago the glacial period made a clean sweep over wide areas, and decimated the vegetation of neighboring regions, so that when it was at an end nature had to begin planting the ground anew. This surely is one of the causes of the poverty of species here in the north. Most likely other causes of a physical nature also exist. So far as I can see, the vegetation here in Scandinavia and even in the higher north might really have been much more rich in species than now is the fact; *only it has had no time* for that, but for every century or, better, millenium that passes, other species, even without the help of man, will immigrate and mix themselves with the old ones, and new species will arise.

---

[3] Proceedings of the Royal Physical Society of Edinburgh 10.

Of course this variety, which is one of the characteristics of tropical nature, also shows itself through *that immense mass of curious ecological adaptations* which we know or eagerly try to discover. There is a great difference between the objects of botanical exploration during the first five or six decades of this century, and those of the later decades. It was Darwin's monumental work that led science into new ways. Formerly the botanists especially wished to discover the many unknown genera and species. Now it is *life* itself they wish to study, those wonderful relations of the varied and often very complicated reciprocity of action between living beings, of which a great deal is already known, such as mimicry, the fecundation of plants by insects, the adaptation of epiphytes and other plants to surrounding nature, ant-loving plants, insectivorous plants, parasitism, and other ecological facts. These are mostly to be looked upon as directly and entirely independent of climate and other physical conditions, while the number of them will hardly be understood, unless, as Wallace has done, we take into consideration the probably uninterrupted process of development of tropical nature through geological periods.

Now we must acknowledge that within the tropics the richness of forms is different in different situations. Even the small Lagoa Santa shows a striking example of this, for the forest is twice as rich in species as are the campos, although the area of forest is much smaller than the area of campos. The relative number of species is about 1600 belonging to the forest, and 800 to the campos. The forest also is much richer in families and genera. Of the 149 families of vascular plants living on the whole area no less than thirty-seven are peculiar to the forest, while but two are peculiar to the campos, and, moreover, each of those two is represented by but one species. Further, of all the genera (about 750) 364 are to be found only in the forest, while only eighty-two are peculiar to the campos.

Here, again, we meet the question, why this difference? In this case I suppose physical conditions to be the causes, although historical facts possibly may be of importance. To be able to understand this evolution of species it is necessary to know whether the campos flora was the primeval one on the old Brazilian highland; or whether from the first the forest covered the country and, later on, forced by physical alterations, retired from the higher and drier parts of the country, where the campos arose, beginning with forest species that adapted themselves to the new conditions. About this, however, I am not able to say anything; we only know that for endless times there must have existed open and woodless land in the interior of Brazil, seeing that Lund has found here remains of now extinct species of the horse and llama types; that is, remains of animals that could only live in a woodless country. I myself feel inclined to suppose that the forest vegetation is the primary one, and for that reason also the richest, while the campos vegetation is the younger one; for most likely the moisture of the climate was much greater when only the inner highland was above the sea, and as the country grew larger in every direction the climate gradually grew drier and drier.

Between the forest and the campos vegetation there seems to have been, in a physical way, originally but one difference, namely, the unequal moisture in the soil. For the soil in which the two different vegetations live is in origin and composition evidently all one, namely, the before mentioned red clay, a product of the decomposition of the primeval rock. But in the valleys, where the forest reigns, the soil is richer in water, and it is my opinion that the water after all is the most essential cause of the distribution of plants, the physiognomy of the vegetation, and the ecological stamp of the vegetation formations. It has been very much disputed whether it is the chemical or the physical qualities of the soil that are the principal causes for the distribution of plants; as to the vegetation formations it is my opinion that we find the principal cause in the quantity of water the soil is able to receive and keep, no matter whether this is owing to physical or chemical causes. Difference in richness in water was the condition for the occurrence of these two formations, but in the course of time the forests improved the soil by their own work, constantly accumulating more or less of humus. In the campos, on the contrary, the sun desiccates the fallen leaves, which crumble into dust and disappear. One thing more; the forest gives shade to a good many species that are not able to endure intense light. Hence the forest affords physical conditions for a vegetation that is not to be found in the campos, and most likely this is the essential cause of the great richness of the forests in species. Favorable conditions of vegetation seem also to entitle one to suppose a more profuse origination of species.

If we compare the Brazilian campos with similar regions in another part of South America, the Venezuela savannas, which seem to possess the very same physical conditions and where a corresponding vegetation has developed itself, I believe we shall learn to some degree the importance of *historical* facts. A few months ago I traveled in Venezuela. At the sight of the savannas I was overcome with the greatest surprise and even joy. Never should I have expected to find such a striking conformity with the Brazil campos. I felt as if I were removed to the campos near Lagoa Santa, thirty degrees of latitude south of Venezuela, and there arose in my memory the happiest years of my youth.

When one is traveling from Puerto Cabello through the country to Valenzia, and has reached the high passes of the coast mountains, the continuous forests suddenly cease, and one has a wide view over a woodless country, partly plains, partly mountains, whose jagged outlines and water furrowed faces stand out sharply in the sunbright air. Far to the south behind the lake of Valenzia, one may see other blue looking mountains, and behind those lie the Llanos. In Brazil one meets quite the same experience. When one has traveled through that much broader border of forest-clad mountains which rim the Brazilian coast, and from the heights of Serra da Mantigueira looks down over the campos country, one sees the clouds cross the coast range of mountains, roll part way down the western slopes, and dwindle away in the dry air of the sunny campos ; just as in Venezuela the clouds pass over the Caraibic mountains and disappear where the dry savanna country begins. The soil seems to be like the Brazilian ; it was the same red clay, or at all events much like it, and here and there rich in sharp-edged gravel. There was on it the same carpet of high grayish grasses and other herbs, and here and there the same stunted trees, with the same coarse leaves, and even with trunks blackened by savanna fires, just as around Lagoa Santa ; it was the very same form of vegetation and even to some degree with the same species as in Brazil. Only one thing I found different, the quantity of species. Those savannas evidently were *much poorer* than the campos of Lagoa Santa. Only a few species of trees were found here on an area which at Lagoa Santa would have been in possession of six to eight times as many. I must admit that it was a rather short visit I could pay those savannas, but my impression is quite in accordance with the experience of other travelers in the Llanos and other parts of Venezuela, for instance the valley of Caracas. This tract, with its 125 square kilometers, contains, according to Ernst, 104 species, and he considers the flora of Llanos as a degenerate offspring from that of the surrounding countries, without endemic genera. As in all essentials the physical conditions of the campos and the savannas seem to be identical, the cause of the poverty of the latter surely is a historical one, and most likely the following.

In the Tertiary period an ocean rolled its waves over these plains that are now covered by the savannas of Llanos and the forests of the Orinoco and the Amazon. When at last the bottom of the ocean got above the sea level, plants from the surrounding highland immigrated, and the resulting vegetation got its stamp from the physical conditions. Where the ground all the year round was moist and the rainfall abundant arose the dense forests and marshy land along the Orinoco and other rivers; and where the ground was dry, at all events periodically, the savannas resulted. In the forests and on the marshland the number of species certainly is very large on account of the extraordinarily favorable physical conditions of the place, while in the savannas, on account of the dryness, the development of species has been much slower. If then we compare the savannas with the campos of Brazil, the main cause of the difference in richness, the existence of which I must suppose to be real, seems to spring only from the difference pointed out in the age of the two vegetations. On the highland of Brazil, vegetation surely has existed as early as any plants existed on earth, but on the savannas of Venezuela they first arrived after the Tertiary period. Here in the north of Europe it is the glacial period, in Venezuela it is the late uplift of the earth's crust that is the cause of the comparative poverty of species.

Thus we see how both physical and historical factors may act in many ways upon the flora of different parts of the world and imprint upon them a different character in respect to the richness of species. It is not at all easy to determine the respective influence of the two groups of factors; only we may suppose that as to the richness of species the *historical* ones are the most important. Now I should like, as far as in this short hour it is possible, to instance how *physical* facts act upon the tropical vegetation, and give it another look than that of our northern one. For that purpose I shall speak briefly of the three vegetation formations already mentioned, and most general of all: the *forest*, the *scrub*, and the *savanna;* but before I do so, I shall remind you of the physical factors, *light* and *heat*, both of which in my opinion are of prime importance for the physiognomy of vegetation.

As to the *light*, I shall remind you of the fact, that only in the light the plant becomes green, and only by aid of it and of green coloring-matter—the chlorophyll—can organic matter be formed. Without light and chlorophyll no organic matter would come into existence. Thus in the household of nature the importance of light and chlorophyll is enormous. But on the other hand chlorophyll may be destroyed by light, and the destructive action may be greater than the constructive. Certainly for every species of plant an optimum light exists; if this be exceeded, many, perhaps all, green plants are in possession of one or another means by which they protect themselves against too intense light.

Closely connected with the light is transpiration, which is dependent not only on the heat and moisture of the air, together with several other factors, among them those internal to the plant itself, but even upon the intensity of light, since the light is converted into heat. By a too profuse transpiration the plant wilts. Against this the plant must have means of defense, and these are partly the same as those that protect against too intense light.

As before mentioned, the water in the soil is of prime importance for building up the plant and for the production of different types of vegetation, and for their distribution in the landscape.

Taking into consideration these facts, besides the high degrees of heat and the intense light of the tropics, we may easily understand the differences of the tropical plants from those of our northern climates. Against too intense light and too profuse transpiration the tropical plants have to struggle, and that struggle imprints its stamp upon them. As in physical respects there are only differences of degree, not of kind, between the two regions we are comparing, it is but natural that the plants in their structure also show only differences of degree. The same characteristic structures we find in the tropical vegetation we may also find in our own northern one, only they are here much more faint and rare.

The first vegetation formation I wish to speak of is the *forest.* The uniformity of climate in respect to the moisture, especially of the soil, gives to the forest its stamp.

At a distance the tropical forests are like our own northern forests of foliiferous trees, possessing the same mellow and rounded outlines, but the *foliage is differently colored,* which seems only natural in consequence of the many different species. Further, the trees are all of a much darker hue than those of ours; at all events, I have never seen a tropical forest with those fresh, bright green colors, that we love and admire in our own birch and beech woods in spring. This difference in coloring is easily understood. The everlasting summer of the tropics and the unceasing development of tropical nature have been very often spoken and written about. Bates says: "There is neither spring, nor summer, nor autumn, but every day is a combination of them all." Really he is partly right. To be sure, the stamp of death or sleep impressed upon our woods of foliiferous trees by the winter is unknown in the tropics, where the trees, on account of the uniformity of the climate, are mostly evergreen (except a very few), as are our coniferous trees and also many of our small brushes and herbs even in Greenland. But we must not believe that life and development are of the very same intensity all the year round, so that every species of tree is getting new leaves, flowers, and fruits at all times of the year. With exception of a very few herbs, such an unceasing process of development is, according to my experience, not to be found anywhere. Near Lagoa Santa, at all events, every species has its time of rest, and at distinct times for the different phases of life. There is plainly a time of spring, namely, from August to October, and there is plainly a winter time; there is a settled leafing and a settled fall of the leaf; but in this the tropical forest shows a great deviation from our woods of foliiferous trees. Our foliiferous trees unfold their leaves in May and lose them in October; nearly six months the leaves remain on the trees. But how long time a tree will keep its leaves depends partly upon the physical conditions, hence the same species in other conditions more favorable for the life of plants may keep its leaves longer. In the tropical forests, with their uniform physical conditions, the leaves may live much longer, though most of them are not able to live for more than one year, and only a few may remain for two years. They do not fall before new leaves have appeared, but none of them is able to reach the age of the acicular leaves of our pine trees. This long duration of the old leaves causes the almost unaltered dark hues of the tropical forest.

During my last journey in the tropics one of the characteristics of the forest trees that attracted my attention was the frequency of highly glistening leaves. Everyone knows the glistening leaves of the rubber tree, *Ficus elastica*, and of our own Christ's thorn, *Ilex Aquifolium*, and in some smaller degree of other trees, though most generally the leaves of our trees are dull green. In the tropics the gloss of the leaves is much more marked; everywhere one may see the dark green leaves reflect the light, and even such plants as the cocoa tree, the plantain, the Indian corn, and the sugar cane have something of that gloss which is especially associated with the dark green, stiff, and leathery, long-lived leaf. Of course, this gloss depends upon certain anatomical structures, and it seems to be, directly or indirectly, a defense against too intense light.

Another fact that gives the tropical forest an aspect different from that of our own forests of foliiferous trees is the large, bright spots of yellow, white, red, purple, and other tints that from time to time are to be seen here and there, when one or another of the woody plants or climbers is in blooming and covers itself with flowers out of number. This phenomenon shows us both the sparseness of the individuals and to what degree the flowering of every species is fixed to a certain time of the year. It is said that almost all species are flowering all the year round, but this is unquestionably an error. An explanation of this misstatement we find in the fact that different species have a different flowering time, some of them even blooming in the winter, that is, in the dry season, and in consequence we may find flowers at almost all times of the year. In Lagoa Santa grows a water lily, *Nymphæa Amazonum*, and if any plant could be expected to show continuous growth such a one in a tropical lake should do so, even though it were an annual, which it hardly is. But at the beginning of the dry season this plant disappears from the surface of the lake, and not until the rainy season has come, in October, do the leaves and afterward the flowers appear anew. The very same fact, though not so distinctly, we find in the case of other water plants that are decidedly perennial.

The *second* type of vegetation I wish to speak of I have seen in Venezuela and in the Danish West Indian islands; it is the dry bushes or *scrub*. Hardly any vegetation can be more disagreeable and ugly than this scrub of brambles and thorns. Thorny cactus and agave plants, with grayish and brownish hairy leaves, that in the dry season partly fall; everywhere a baking heat and dryness, in some places an immense number of gnats; such is, in short, this scrub which we in northern regions never saw the like of; only in the Mediterranean countries, in the so-called Maquis, do we find anything similar.

In a most striking manner the scrub shows us how the physiognomy of the vegetation depends upon physical conditions. These bushes have to defend themselves against too intense *drought*, *heat*, and *light*. The outer and inner construction of every species bears an impress of that. The grayish hairy coverings, especially remarkable in the species of Croton, that give the whole landscape such an ugly appearance, are, in the first place, an excellent defense against transpiration, and this defense may be further strengthened by the rolling up of the leaves. On many Croton bushes I saw how all the leaves that were in shade were flattened, while those that were exposed to the direct sunlight had in different degrees rolled themselves up, so that the under side, which is the more hairy one, curved outward. This defense against drought is not quite unknown to us, only we have to seek it among plants that live upon dry, sandy fields, in the downs, upon the heaths, and in similar localities, which at periods are hot and dried up.

Also in the forests of the tropics one finds these grayish hairy leaves especially on lianas, I believe. Among these plants a xerophilous construction is not uncommon, and why this is the case is easy to understand; for their stems are often many meters in length, with a diameter of a few centimeters; they ascend to the tops of the highest trees, clambering from one to another, and one may see them hanging like long festoons between the trees. Through their slender stems the water is to be lifted from one single root up to the leaves; it has, therefore, an exceptionally long way to travel, and though nature has tried to provide for this by making the vessels of the stems, that is the water-conduit pipes, wider than in any other plants, it is easy to understand that it is, nevertheless, not without benefit to the plant to be able to moderate the transpiration.

In many lianas, as well as in other plants, both in the forest and in the scrub, one finds another peculiarity also that is not unknown in our northern vegetation, but is much more frequent in the tropics, that is, the latex. When cutting through a tropical scrub every moment one will have an opportunity of seeing the latex dripping in large white drops from the wounded stems. We do not yet understand the importance of latex in the life of plants; different hypotheses have been presented, but none generally accepted. Most likely the latex serves several purposes, and one of them, I suppose, is to supply water to the leaves in times of need, when the transpiration becomes too profuse. If the latex tubes really have this task, looking upon them from an anatomical standpoint, we must admit that their structure is exceedingly suitable to the purpose.

The scrub also shows other remarkable examples of defense against too intense light and profuse transpiration. However, I shall mention only one. While wandering in the scrub my attention was attracted by the difference between the numerous thorny acacia bushes and the other plants. The acacias did not have the leathery, dark green, glossy leaves peculiar to so many forest plants; neither were they gray-felted nor furnished with latex; but in the middle of the dry bush so heated by the sun the plants stood with their strange lusterless, dull green and moreover extremely delicate and finely compound leaves. It was not difficult to discover that they had another defense, and one developed even to perfection against the intense light and transpiration; I refer to the photometric leaves that by an exceeding sensitiveness for the optimum of light adjust themselves readily to the different amounts. In the gentle morning light the leaflets are extended flat, intercepting as many of the rays as possible. But later in the day, when the sun is rising higher and the heat is growing more intense, the leaflets fold themselves more and more together and upwards like a closing book, the consequence of which is that the light strikes the plane of the leaf at acute angles, by which its effect becomes weakened. Thus the leaf itself regulates the light and the transpiration, and the different aspect of the acacia bushes at different times of the day is not quite without influence upon the physiognomy of the landscape.

This phenomenon, as well as others, we find also in our northern climate; for instance, one finds the leaflets of the wood sorrel, *Oxalis Acetosella* in our forests differently placed with respect to the different light of the day.

The *third* type of vegetation I want to speak of is the *campos* or *savannas* already mentioned. To find anything like them one would have to go to the grass steppes of southeastern Europe. Trying to compare the savannas with our own grass fields and meadows, one finds a great difference in physiognomy as well as in ecology. The savannas have a dry or, at all events, at periods a dried up and hot soil; their grasses are coarse and stiff, grayish and hairy, and only fresh green in their first and short youth. And even admitting that the campos of Brazil especially are much richer in flowers than are our meadows, and that the flowers of the campos are much larger and with more gaudy colors than ours, I must say that the wonderful freshness and charm so peculiar to our green, luxuriant, thick, and soft meadows and grasslands I have never seen anywhere, with the exception of a very brief time in the early spring.

The same is true in reference to the vegetation of the forest ground. Nowhere have I seen such soft, swelling, and fresh green moss carpets as those in our woods of coniferous trees, and nowhere have I seen such a flowering woodland as that of our beech woods in the early spring. The fact is that wherever in the tropics the rainfall is small and the ground dry, the vegetation develops itself either as savannas, or as dry thorny cheerless scrub, or as dry forests poor in mold, though rich in lianas, bushes, and small trees, because of which they are almost impenetrable; or the country becomes, as in the highland of Mexico, almost a desert. But if water is at hand, especially water in the soil, there all sorts of trees, bushes, and herbs will spring up luxuriantly, in an abundance and with a foliage unknown in the north. In consequence of the abundance of water either a forest or a marsh vegetation develops itself. If the soil is especially rich in water, there will be a marsh, with high grassy plants and other herbs, bushes, and even trees, a vegetation through which it is anything but easy and agreeable to walk, and where, moreover, malarial fevers abide. But if the moisture of the soil suits a forest, one with impenetrable masses of trees, bushes, and lianas will be formed. In the dim light of the forest floor, which is covered with leaves and dead branches, mosses grow only with difficulty. On the stems of the trees they struggle with ferns, orchids, and other epiphytes as to which shall keep the place, and they are even forced to migrate to the leaves; but thick, soft, green moss carpets are never found.

Now, with your permission, I shall conclude these descriptions. I have wished to throw into relief at once how historical as well as physical factors enter into and are determining the nature of vegetation in a country, and how, in my view, the *historical* factors are of importance as to the richness in species, while the physical factors are especially important in determining the physiognomy of the species and of the vegetation as a whole. And at the same time, I have desired to draw forth some of the differences between tropical and northern vegetation. I shall sum up my apprehension of tropical nature in the words that Linné is said to have expressed on *Homo sapiens:* "Habitat inter tropicos, hospitatur extra tropicos." Perhaps this saying may be called a true one, remembering that the cradle of mankind most likely was in the rich and luxuriant tropical nature ; but I hold it for certain that outside the tropics man is not a transient guest. For, admitting the tropics to be ever so rich in species, types, flowery pride, and fragrance, and admitting it to be ever so easy for man to procure maintenance of life in this rich nature (and surely it is this Linné has had in view), we must say that outside the tropics, in our temperate climates, man has found his most charming *home*, and just here he develops himself supremely in intelligence, morality, and strength of character.

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THE PRODUCTION OF FLUORESCENT PIGMENT BY BACTERIA.

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A CONSIDERABLE number of different "species" of bacteria have been described as endowed with the property of forming a blue-green fluorescent pigment in suitable media. I append a list, perhaps not complete, of the various "fluorescent bacteria" already discovered.

It is not at all likely that the fifty names bestowed upon these cultures represent as many totally distinct microorganisms, and in some cases it is practically certain that the same bacterium masquerades under several different titles.

The experiments recorded in the present paper embody a series of attempts to discover the conditions under which fluorescence is produced, and especially the nature and amount of the chemical substances essential to the formation of the fluorescing body.

I have chosen for this purpose six different cultures.[1] Four of these do not liquefy gelatin and were sent to me from Kral's Laboratorium under the names *B. fluorescens albus*, *B. fluorescens tenuis*, *B. fluorescens mesentericus*, and *B. fluorescens putridus*. The two others liquefy gelatin; one of them was sent by Kral with the name *B. viridans*, and the second was isolated by me from the water of Lake Michigan and identified as *B. fluorescens liquefaciens* (description by Kruse in Flügge's Die Mikroorganismen **2**: 292).

1. B. FL. ALBUS.— A bacillus was first described under this name by Zimmermann who found it in the Döbeln water supply.[2] The culture bear-

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[1] I have also made some experiments with *B. pyocyaneus*, but, owing to the complication due to the formation of at least two pigments by this bacillus, I am led to reserve my statements on this head for a subsequent communication.

[2] O. E. R. Zimmerman, Die Bakterien unserer Trink- und Nutzwässer 18. Chemnitz, 1890.

ing this name which I have employed agrees closely with Zimmermann's description. The bacilli are small (0.6μ by $1-2\mu$) with rounded ends, and occur both singly and in short chains; they are actively motile. Upon gelatin plates the colonies spread out into a thallus-like expansion and the surrounding medium assumes first a blue-green and later a grass-green tint. The growth on agar is elevated and translucent white, and a green fluorescence is imparted to the medium. The growth on potato is luxuriant, and has a rich chocolate-brown color. Milk is not coagulated, no indol is formed, and nitrate is not reduced. In the fermentation-tube no gas is produced, but the broth is rendered strongly acid. At 37.5° C. a good growth takes place upon agar, but no pigment is produced at this temperature. A perceptible amount of pigment is formed at 33° C.

2. B. FL. TENUIS.— Described by Zimmermann[3] as a distinct species. Found also by Dittrich[4] and regarded by him likewise as a distinct species. Kruse,[5] however, considers this organism as merely a variety of *B. fluorescens non-liquefaciens*. My own culture bearing the name of *B. fluorescens tenuis* agrees very closely with *B. fl. albus*. The chief points of difference are (*a*) its failure to grow at all at 37.5° C.; (*b*) its ability to produce a small amount of indol in sugar-free broth.

The fine, delicate leaf-like growth in streak-cultures, upon which Zimmermann chiefly bases his separation of this "species" from *B. fl. albus*, was noticed sometimes in my culture, but was not constant.

3. B. FL. MESENTERICUS.— Described by Tartaroff.[6] I have not been able to see the original description. The culture sent me under this name resembles *B. fl. albus* very closely. There are slight but inconstant differences in the growth of the two cultures upon gelatin, agar, and potato. The growth at 37.5° C. is much less profuse than with *B. fl. albus* and no pigment is formed when the culture is kept at 33° C. Milk is slightly digested and acquires a feebly acid reaction.

4. B. FL. PUTRIDUS.— Described in Flügge's Die Mikroorganismen, 2d edition, p. 288; cf. also the 3d edition, **2**: 292. My own culture bearing this name agrees in most respects with *B. fl. albus*. The chief differences are (*a*) much scantier growth at 37.5° C.; (*b*) less rapid growth on all media; (*c*) a dry, thin growth on potato, more restricted and duller than that of *B. fl. albus*; (*d*) a much more decided green tinge imparted to milk.

These differences, although slight, have been constant during some ten months of observation. I have not been able to distinguish any difference between the character or intensity of the odor given off by this species and that observed in the three cultures previously described.

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[3] *Op. cit.* p. 16.

[4] Verhandl. d. naturhistor. Vereins zu Heidelberg N. F. **5**: 536. 1897.

[5] Flügge, Die Mikroorganismen **2**: 293.

[6] Die Dorpater Wasserbakterien. Inaug. Diss., 1891.

5. B. VIRIDANS.— A microorganism was first described under this name by Symmers.[7] Zimmermann[8] also described a form found in polluted water which he pronounces wholly identical with a culture of *B. viridans* (Symmers), obtained from Kral. My own culture bearing this name was sent me from Kral's collection.

The bacilli vary considerably in dimensions when grown on different media. They are short and quite slender in broth cultures, longer and plumper on potato. On the latter medium they average about 0.8–0.9μ by 2.5–3μ. They occur usually singly or in pairs when grown in broth, and are non-motile. They stain with the ordinary aniline dyes, but not so readily as with carbol-fuchsin or Löffler's methylene blue. They do not retain the stain by Gram's method. Gelatin is liquefied very rapidly, the growth in a stab-culture occurring at the upper part of the inoculation line and giving rise to a saucer-shaped depression. The growth in agar streak-culture is gray, thin, fairly spreading and with serrated edges. The medium is speedily colored a fine blue-green which in seven days has changed to a dark Nile-green. The growth on potato is luxuriant, at first dry and of a tan-color, but later becoming dark and slimy. Milk is curdled with acid reaction, and the whey assumes a decided green color. No indol is formed, and nitrate is not reduced. In the fermentation tube no gas is produced in glucose bouillon but the medium becomes strongly acid. At 37.5° C. a very scanty growth occurs, but no pigment is produced.

Zimmermann[9] classifies this organism as one that produces green, but not fluorescent pigment. I have not been able to remark the existence of any such difference between my culture of *B. viridans* and the other organisms I have studied; fluorescence is manifest in all.

6. B. FL. LIQUEFACIENS.— A germ isolated by me from the water of Lake Michigan. I have given it the above name, since the culture agrees with the description of the species by Kruse.[10] The chief differences between this culture and that of *B. viridans* are the following: (*a*) no growth at all occurs at 37.5° C.; (*b*) growth in gelatin stab-cultures is more rapid than that of *B. viridans* under the same conditions, but pigment is less abundantly produced; (*c*) the bacilli are actively motile; (*d*) growth on potato is from the outset moist and slimy; (*e*) nitrate is readily reduced to nitrite.

It is evident from these descriptions that the existing differences between some of the cultures I have employed are hardly to be regarded as specific, whatever may have been the case with the type microorganisms when first isolated. I shall for convenience, however, refer to the cultures by the names they bear just as if they were so many distinct "species."

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[7] British Medical Journal **2**: 1252. 1891; cf. also Brit. Med. Journ. **1**: 113. 1893.

[8] *Op. cit.* **2**: 22.

[9] *Op. cit.* **2**: 30.

[10] Flügge's Die Mikroorganismen, *loc. cit.*

The methods employed have been selected with a view to obtaining constancy and uniformity of conditions. Owing to the familiar fact that the different commercial peptones vary widely in chemical composition and nutritive value, and since Gessard[11] and Lepierre[12] have definitely proved that the production of fluorescence by certain bacteria is profoundly affected by the nature of the peptone used, I have carried out my investigations with the aid of simple solutions of chemical compounds whose molecular composition and arrangement are more accurately known. The nitrogenous basis of these nutrient media has consisted of asparagin or ammonium salts, and to these have been added other substances according to the nature of the experiment. The utmost care has been taken to obtain chemicals of strict purity, since a mere trace of foreign substance is in some cases sufficient to vitiate the result.

In all of my solutions I have employed water redistilled in glass. The various flasks and test-tubes used in my experiments have been thoroughly cleansed with chromic acid cleaning mixture which has been very carefully washed out and the vessels finally rinsed in distilled water. A suitable quantity (usually $7\text{–}8^{cc}$) of the nutrient solution has been placed in thin-walled test-tubes and sterilized in the steam-bath by the discontinuous method. Prolonged heating and the use of the autoclave have been avoided as they have been found to affect the constitution of some of the media.

Inoculation of the media has usually been made from vigorous agar growths about three to five days old, but I have also often used for this purpose fluid media in which abundant production of pigment had occurred, *e. g.*, an asparagin-phosphate-sulfate solution, but without noting any difference in the outcome.

The cultures have always been kept in the dark and at the room-temperature, 18–20° C., except when specified otherwise.

[11] Ann. de l'Inst. Past. **6**: 801. 1892.

[12] Ann. de l'Inst. Past. **9**: 643. 1895.

The most extended contribution to our knowledge of the fluorescent bacteria, with the exception of Gessard's classic papers upon *B. pyocyaneus*, is contained in a paper by Thumm.[13] My own observations conflict with Thumm's at some points, while the conclusions I am compelled to draw from my results are, in important respects, so at variance with his that I do not hesitate to reopen the whole question and to present the record of my experiments in some detail.

INFLUENCE OF THE CHEMICAL COMPOSITION OF THE MEDIUM.

In 0.2 per cent. pure asparagin solutions a very slight turbidity occurs, but no trace of color. If 0.1 or 0.5 per cent. of chlorid (sodium, calcium, magnesium, or potassium) be added to the asparagin solution, the turbidity is slightly increased, but no pigment is formed. Sulfates (sodium, magnesium, or potassium) in the same proportion aid the growth more than chlorids, but no color appears. Pure phosphates (sodium, magnesium, or potassium) are yet more favorable to growth, but fluorescent pigment still fails to develop. I must at this point lay stress upon the importance of obtaining chemically pure phosphates. A mere trace of sulfate in the presence of phosphate, as I shall show presently, is sufficient to lead to the production of pigment. I have found that many samples of "C. P." phosphate obtained from reliable manufacturers contain a quantity of sulfate sufficient to vitiate the results, and I have consequently been compelled to prepare pure phosphates by recrystallization or by thorough washing.[14]

If the various species be grown in a solution of 0.2 per cent. asparagin, 0.1–0.5 per cent. sodium (or magnesium) chlorid, and 0.1 per cent. neutral sodium phosphate, the resulting turbidity is but little, if at all, greater than in the asparagin-phosphate solution alone. If, however, 0.1 per cent of sulfate (sodium, magnesium, or potassium) be added to the asparagin-phosphate solution, abundant multiplication takes place together with a rich development of the fluorescent pigment.

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[13] Beiträge zur Biologie der fluorescierenden Bakterien. Arb. d. Bakteriol. Inst. d. grossh. Hochschule zu Karlsruhe, 1895.

[14] I am indebted to my friend Professor Stieglitz for many suggestions regarding the preparation and testing of pure salts.

To determine the amount of sulfate necessary for the production of the pigment, solutions were prepared containing 0.2 per cent. asparagin; 0.1 per cent. neutral sodium phosphate; and respectively 0.1, 0.01, 0.001, 0.0001, and 0.00001 per cent. magnesium sulfate. All of the species except *B. fl. putridus* produced pigment in the presence of 0.01 per cent. and 0.001 per cent. sulfate nearly as well as when 0.1 per cent. was used; with the smaller amount of sulfate, the development of pigment was slower, but the final result almost as intense. With 0.0001 per cent. of sulfate a good development of color was brought about by all five species. In the presence of 0.00001 per cent. of sulfate *B. viridans* alone showed any well-defined development of pigment. There was the merest trace of color in *B. fl. mesentericus*, and the others were entirely without a tinge.

The nature of the base associated with the phosphorus and sulfur appears to be a matter of complete indifference. Sodium, potassium, and magnesium salts gave similar results in whatever way they were combined. Even if ammonium phosphate and ammonium sulfate be used together, fluorescence appears, but it is somewhat less intense than in the presence of one of the bases mentioned above.

To determine the amount of phosphate necessary for the formation of pigment, solutions of 0.2 per cent. asparagin, 0.1 per cent. magnesium sulfate, and varying quantities of neutral sodium phosphate were inoculated in the usual manner. In the asparagin-sulfate solution containing 0.001 per cent. of the phosphate, good color was developed by all the species, being deepest in the cultures of *B. viridans* and *B. fl. mesentericus*. In the same solution containing 0.0001 per cent. of phosphate no pigment was developed by any of the species; the turbidity was, however, slightly more pronounced than in the control tubes of simple asparagin-sulfate solution.

These organisms are able to produce the fluorescent pigment for a series of generations in such simple media as I have used. In a solution of 0.2 per cent. asparagin, 0.1 per cent. sodium phosphate, and 0.0001 per cent. magnesium sulfate, *B. fl. albus* is able to develop a fairly intense color. If from a culture in this medium a second tube of the same solution is infected, and the procedure repeated at intervals of three days, neither attenuation nor exaltation of the fluorescigenic power can be noticed after thirteen successive transfers. The same statement holds true of the action of *B. fl. putridus* in a solution containing 0.25 per cent. ammonium lactate, 0.1 per cent. sodium phosphate, and 0.1 per cent. magnesium sulfate.

The solutions of the ammonium salts of the organic acids, with the exception of the urate, contained respectively 0.5 per cent. of the ammonium salt and 0.1 per cent. each of neutral sodium phosphate and magnesium sulfate. Ammonium *succinate*, *lactate*, and *citrate* all proved to be substances well adapted for the production of the fluorescent pigment. The color appears more speedily in the succinate and lactate, and with most species becomes also more intense than in the citrate.

In the *succinate* solution all of the species but one developed pigment quickly and intensely. The color developed very tardily in the culture of *B. fl. putridus*, and never became intense. In ammonium *lactate* solution, a fine color developed within two days in the cultures of *B. fl. albus*, *B. viridans*, *B. fl. tenuis*, and *B. fl. mesentericus; B. fl. liquefaciens* was from ten to twelve hours behind the others at this stage, but eventually produced a very deep color; *B. fl. putridus* showed a much fainter tinge of color after ten days, and the color never became pronounced.

The ammonium *citrate* solution did not, on the whole, lend itself to the production of pigment quite as readily as the lactate and succinate. *B. fl. albus*, *B. fl. tenuis*, and *B. fl. mesentericus*, indeed, seemed to flourish and produce pigment nearly as well as in lactate or succinate, but *B. viridans* and *B. liquefaciens* showed a decidedly less rapid growth, while *B. fl. putridus* caused only a very slight turbidity and developed no trace of color.

Ammonium *tartrate* solution afforded one of the most interesting examples of a difference between the cultures employed. *B. fl. albus* produced a rich coloration of the medium within the space of twenty-four hours. On the tenth day *B. fl. tenuis* likewise showed a slight tinge of color, and this slowly but steadily deepened, until, on the twenty-fifth day after inoculation, the color was as decided as in the tubes of *B. fl. albus*. None of the other species showed the slightest development of pigment, although a marked turbidity manifested itself in the tube inoculated with *B. fl. liquefaciens*, and a perceptible cloudiness appeared in the culture of *B. fl. mesentericus* and *B. fl. putridus*. The difference in the behavior of the several species in this solution was so striking that I repeated the experiment several times, always, however, with the same outcome. It is interesting to note in this connection that Thumm[15] states that the only species (among *B. fl. albus*, *tenuis*, *erythrosporus*, *putridus*, and *viridans*) that was able to produce fluorescent pigment in a tartrate solution (ammonium tartrate 0.5 per cent., potassium phosphate 0.05 per cent., magnesium sulfate 0.01 per cent., calcium chlorid 0.005 per cent.) was the one bearing the name of *B. fl. albus*. Thumm gives no description whatever of the various "species" that he used, but they were probably derived from the same sources as my own cultures. Thumm's culture of "*B. fl. tenuis*" is recorded (p. 84) as showing "slight turbidity: no production of pigment" in the tartrate solution, while my culture designated by the same name is able to form a notable quantity of pigment, although more tardily than *B. fl. albus*. In ammonium *urate* solution (urate 0.05 per cent.,[16] sodium phosphate 0.1 per cent., magnesium sulfate 0.1 per cent.), *B. fl. liquefaciens* produces pigment more rapidly than the other species, but at the end of seven days *B. fl. mesentericus* and *B. fl. tenuis* rival it in intensity, and after eighteen days growth *B. fl. albus* shows quite as deep a color as the species already named. There is at this time the merest dash of color in the tube of *B. viridans*, and none at all in that of *B. fl. putridus.*

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[15] *Op. cit.* p. 84.

[16] On account of the comparatively slight solubility of the urate a smaller quantity was used than of the more soluble ammonium salts.

Ammonium *acetate* solution gave on the first trial a slight turbidity with *B. viridans*, but no sign of growth with any of the other species. The acetate solution was found, however, to have quite a decided acid reaction, and on rendering it slightly alkaline with ammonia, all the species except *B. fl. putridus* became able to produce a very considerable quantity of pigment.

Ammonium *oxalate* solution is not adapted to the production of pigment although capable of supporting growth. *B. fl. albus* and *B. fl. tenuis* cause decided turbidity, but never develop any trace of fluorescent pigment even when alkali is added to the medium. The other species show varying degrees of cloudiness. If a more dilute solution be employed (0.05 per cent. oxalate), a faint tinge of color appears in the culture of *B. fl. liquefaciens*, and the merest suggestion of fluorescence is shown in the tubes of *B. fl. albus*, *B. fl. tenuis* and *B. fl. mesentericus.*

In ammonium *formate* solution the conditions for growth and pigment production are still less favorable than in oxalate; in the ordinary solution the tubes remain perfectly clear. If the solution be made slightly alkaline, however, a faint tinge of color appears in the culture of *B. fl. liquefaciens*, but the other species, while producing a slight turbidity, never form pigment.

INFLUENCE OF CONCENTRATION OF THE MEDIUM.

Considerable influence upon the production of pigment is exerted by the degree of concentration of the medium. In Uschinsky's solution,[17] which consists of glycerin 30–40^{gm}, sodium chlorid 5–7^{gm}, calcium chlorid 0.1^{gm}, magnesium sulfate 0.2–0.4^{gm}, di-potassium phosphate 2–2.5^{gm}, ammonium lactate 6–7^{gm}, sodium aspartate 3–4^{gm}, dissolved in 1000^{cc} of water, some of the species, notably *B. fl. albus* and *B. fl. mesentericus*, grow luxuriantly and produce a goodly quantity of pigment, but the intensity of color never reaches as high a point as in some of the simpler solutions, and the color assumes much earlier the yellow tinge which overtakes all old cultures. Some of the species, as for example *B. fl. putridus*, are unable to grow in Uschinsky's medium, and the tubes, although inoculated from a young active culture, remain perfectly clear. There is some lack of uniformity in regard to the behavior in this medium. *B. viridans* and *B. fl. tenuis*, for example, will sometimes multiply and produce considerable turbidity without forming pigment, and at others, under apparently identical conditions, will refuse to grow at all. The presence of glycerin is one of the unfavorable factors. If the medium be diluted 1:5 or 1:10, all of the species are able to grow and produce pigment.

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[17] Centralbl. f. Bakt. **14**:316. 1893.

A medium somewhat similar to Uschinsky's, but simpler, was compounded by Fränkel.[18] This consisted, in its final modification, of sodium chlorid 0.5^{gm}, ammonium lactate 6^{gm}, asparagin 4^{gm}, neutral sodium phosphate 2^{gm}, dissolved in 1000^{cc} of water. The solution was either amphoteric or slightly acid, and was made slightly alkaline "with a small quantity of caustic soda." In my early experiments all the species grew quite luxuriantly in this medium, but never produced any fluorescence, although the old cultures usually had a yellow tinge. The reason for this failure to produce pigment might at first be supposed to lie in the absence of sulfate, especially since color is developed when sulfate is added to Fränkel's medium. But that this is not the whole explanation is shown by the fact that, if the original medium was diluted 1:10, a very fair development of pigment took place. Investigation showed that some of the ingredients of the solution were not perfectly pure, but contained a trace of sulfate. The quantity of sulfate present, however, was not sufficient to permit of pigment production in the strong solution, although one-tenth of the same quantity was sufficient to permit of pigment production in a less concentrated medium. If Fränkel's medium be prepared with perfectly pure chemicals no pigment production occurs even when the solution is diluted.

The effect of concentration is well shown also in experiments made with solutions of high phosphate content. In solutions of

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[18] Hyg. Rundschau 4:700.

0.2 per cent. asparagin, 0.0001 per cent. sodium sulfate, and, respectively, 1, 0.5, 0.2, 0.1 per cent. neutral sodium phosphate, *B. fl. albus* develops pigment most rapidly and intensely in the 0.1 per cent. phosphate solution. *B. fl. putridus* and *B. fl. tenuis*, on the other hand, develop pigment soonest in the 1 per cent. phosphate solution, and the former species does not develop any at all in the solutions with slighter phosphate content. As a rule, however, especially in solutions containing a larger amount of sulfate, a phosphate content as high as 1 per cent. interferes with the production of fluorescent pigment and the culture generally assumes a muddy yellow tint. The same thing occurs if a considerable quantity of ammonium salt be employed. *B. fl. albus*, for example, in a solution of 2 per cent. of ammonium tartrate and the usual quantities of phosphate and sulfate, imparts less of a fluorescent tinge and more of a yellow color to the medium, than with the ordinary 0.5 per cent. tartrate solution. This fact is of interest in connection with Lepierre's conclusions,[19] which are based upon experiments made with 2 per cent. solutions of ammonium salts. The high acidity of such strong solutions as he employed, however, was probably an even greater factor in the vitiation of his results than the simple concentration of the medium.

INFLUENCE OF LIGHT UPON PIGMENT PRODUCTION.

Pigment production is perceptibly affected by light. I have made no experiments with regard to the action of direct sunlight, but have confined myself to a comparison of cultures kept in the dark with others kept in diffuse daylight. The latter cultures were kept on a desk near the windows of a room into which no direct sunlight, but only north light entered; the former were kept in a locker in the same room and as nearly as possible at the same temperature, although variations of from three to four degrees were occasionally observed. These slight temperature variations were, however, sometimes on one side, sometimes on the other, and I have seen no reason to infer that the course of pigment production is materially influenced by such slight fluctuations. It has invariably happened in these experiments that the cultures kept in diffuse daylight show a distinctly fainter color than the control tubes kept in the dark. In several instances fluorescence failed to appear in cultures grown in the light. This is true, for example, of a culture of *B. fl. albus* in a solution of 0.2 per cent. asparagin, 0.1 per cent. sodium phosphate, 0.0001 per cent. magnesium sulfate. In other solutions too, in which the amount of pigment produced is at best not great, a similar complete inhibition of the fluorescigenic power can be noticed. Thumm (*l. c.*) does not state whether the cultures in his experiments were kept in the dark or in the light, and it may be suggested that if the latter was the case some of his negative results (as, for example, that with *B. fl. tenuis* in ammonium tartrate solution) might be accounted for.

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[19] Ann. de l'Inst. Past. 9:643. 1895.

The question whether in such cases the light acts upon the pigment or upon the metabolic activity of the bacteria is a difficult one to come at. The turbidity of cultures kept in the dark and in the light seems to be about the same. If cultures in which abundant pigment production has taken place be transferred to the light (this was done with a set of cultures in ammonium succinate solution), a very slight fading out can be noticed at the end of two weeks. The fading is accelerated by placing the tubes on the window-sill (north light), but even after the expiration of three weeks no very extensive divergence can be noted when the tubes are compared with the control tubes which have remained all the while in the dark. The cultures of some species, however, show a greater tendency to fade than others; the pigment produced by *B. fl. albus* fades out quite readily, while that formed by *B. fl. tenuis* retains its brightness with comparative persistence. The fading out consists in the gradual yellowing of the pigment, which continues until all trace of green is eliminated; cultures kept in the dark show the same change, but it takes place, as I have indicated, more slowly. The change is probably one of oxidation, and the acceleration of the process in the light is precisely what might be anticipated.

The addition of an oxidizing agent, as dilute potassium permanganate, has a similar etiolating effect upon the pigment.

INFLUENCE OF THE REACTION OF THE MEDIUM.

The presence of acid checks the production of pigment Even in slightly acid solutions where considerable multiplication may occur, pigment is not formed. The interference of the acid seems to be rather with the metabolic activities of the bacteria than with the pigment, as the following facts indicate. The pigment when it is once formed is not destroyed by acid, but simply rendered invisible. If a few drops of acid be added to a finely pigmented culture of any of the species employed, the color is completely discharged, but the addition of alkali brings it back as vividly as ever. On adding acid again and then alkali the same change again occurs, and this can be repeated for at least six times upon the same culture without any perceptible weakening of the intensity of the pigment. When, furthermore, a well-developed culture is made quite strongly acid with HCl and allowed to stand for twenty-four hours, the color reappears when alkali is added with the same intensity as before. The existence of an aphanochromatic substance, at one time conspicuously visible in the form of the fluorescent pigment, at another colorless and not apparent, is clearly demonstrated by these experiments. This substance, however, is not formed in acid solutions.

The influence of acid upon the pigment is beautifully shown in the fermentation tube where the pigment acts as an indicator. In 3 per cent. glucose-broth (prepared from broth freed of muscle-sugar by the method suggested by Theobald Smith[20]), *B. viridans* for the first four to five days after inoculation develops no pigment although the broth becomes very turbid. No color appears when alkali is added to the broth at this stage, conclusively showing that the presence of acid interferes with the production of the pigment or its aphanochromatic double and does not simply mask the presence of this substance. After eight or nine days, however, pigment makes its appearance. In such a nutrient medium, then, there is a struggle between two of the vital activities of this organism, namely, its ability to produce acid and its power to form alkali. The latter "function" in this case ultimately gains the upper hand.

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[20] Journn. Expt. Med. 2: 543. 1897.

In 3 per cent. saccharose broth the course of events is exactly reversed. Saccharose is less easily fermented by this species and the result is that pigment is formed at the outset and a two days' growth is well colored. As the saccharose becomes converted into acid the color slowly fades out and at the end of four days it has vanished.

The pigment formed by all the species is at first, as has been shown by Thumm and others, a delicate robin's egg blue, but as the solution becomes more alkaline owing to the bacterial growth, the color changes to green, and in strongly alkaline solutions is a deep green tint, showing no fluorescence. The addition of alkali to a solution containing the blue pigment produces at once the same change as is wrought more slowly by the alkali formed by the bacteria.

SUMMARY.

The upshot of my experiments may be summarized under the following heads:

1. *The presence of both phosphorus and sulfur is essential to the formation of the fluorescent pigment.*

The effect of almost infinitesimal quantities of sulfate in the presence of phosphate compels us to accept with some reserve the statements made by authors as to the production of fluorescence in media devoid of sulfur. Thumm's curious statement[21] that *B. fl. albus*, while it produces fluorescence in a medium composed of 1 per cent. ammonium succinate, 0.1 per cent. potassium phosphate, 0.04 per cent. magnesium sulfate, 0.02 per cent. calcium chlorid, and also produces a feeble green fluorescence when the magnesium sulfate is omitted, produces no fluorescence at all if the calcium chlorid also be left out, is perhaps most easily explicable on the supposition that a small amount of sulfate was present as an impurity in the latter salt.

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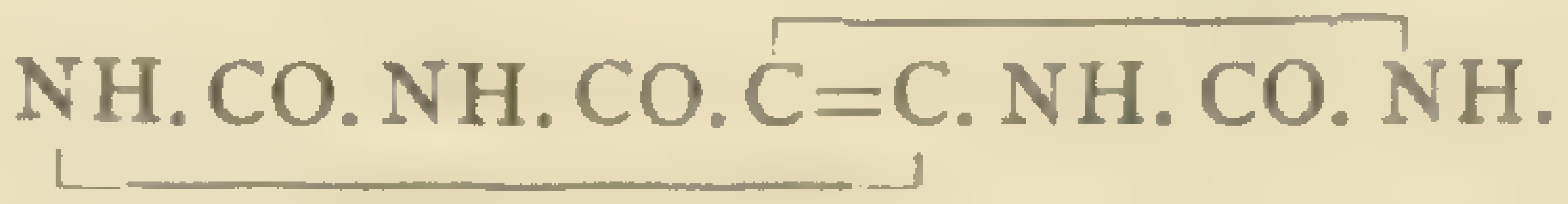
[21] *Op. cit.* 42–43.

2. *The nature of the base associated with the phosphorus and sulfur is not important.*

Thumm observed, as I have done, that the omission of calcium chlorid alone from a nutrient solution containing potassium phosphate and magnesium sulfate exerts no perceptible effect on the production of pigment, but that the omission of the magnesium sulfate alone causes a marked diminution in pigment production; in my own experiments a total inhibition. From this he draws the singular conclusion that "so far as the formation of pigment is concerned, magnesium cannot be replaced by calcium." It is not necessary to point out the fallacy involved in such a deduction.

3. The conclusions that may be drawn regarding the dependence of the fluorescent "function" upon the molecular constitution of the ammonium salts may be best appreciated through an examination of the constitutional formulæ of the organic acids whose salts were employed. The list is arranged, as far as possible, in order of fluorescigenic value.

Asparagin,	$COOH.\ CH_2.\ CH.\ (NH_2).\ CONH_2.$
Succinic acid,	$COOH.\ CH_2.\ CH_2.\ COOH.$
Lactic acid,	$CH_3.\ CHOH.\ COOH.$
Citric acid,	$COOH.\ C(OH).\ (CH_2COOH)_2.$
Tartaric acid,	$COOH.\ CHOH.\ CHOH.\ COOH.$
Uric acid,	 $NH.CO.NH.CO.C{=}C.NH.CO.NH.$
Acetic acid,	$CH_3.\ COOH.$
Oxalic acid,	$COOH.\ COOH.$
Formic acid,	$H.\ COOH.$

Lepierre,[22] who studied the behavior of a species closely related to if not identical with *B. fl. putridus*, draws from his work the far-reaching conclusions that the fluorescence is intimately bound up with: first, the bibasicity of the acid; second, the existence in the molecule of at least two groups of CH_2. Conclusions analogous to these cannot be deduced from my own work. The difference between acetic acid on the one hand and oxalic and formic acids on the other is certainly significant, but that neither the carboxyl (COOH) nor the methylene (CH_2) grouping is essential to pigment production is shown by the availability of urate. The difference between tartrate and succinate, as well as that between formate and acetate does, however, clearly indicate that, other things being equal, the presence of the methyl or methylene group is coincident with superior nutritive value and fluorescigenic power.

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[22] Ann. de l'Inst. Pasteur 9:643.

4. The presence of acid in the medium not merely conceals the existence of the substance to which the color is due, but interferes with those vital activities of the bacilli which, in an alkaline solution, lead to the production of that substance.

5. Diffuse daylight is unfavorable to pigment production.

6. If chemical substances that prove, when in certain proportions, favorable to growth and to the production of pigment be present in excess of a certain quantity, the production of pigment will be checked, although growth may be more abundant than before.

I may add, as an *obiter dictum*, that since the pigment is of no discoverable advantage to the organisms possessing the power of producing it, its production is probably purely incidental and not an essential vital act. The "fluorescigenic function," upon which some bacteriologists dwell, is in my opinion simply the expression of certain changes wrought by the organism upon the nutrient substratum in which it lives. When the substratum contains certain compounds, the metabolic activities of the organism adjust themselves to these conditions and the metabolic products differ correspondingly. It is purely a matter of accident and of no physiological significance that under certain conditions one of these metabolic products happens to be fluorescent.

THE UNIVERSITY OF CHICAGO.

LIST OF FLUORESCENT BACTERIA.

1. Bacillus aquatilis fluorescens (Lustig). Diagnostik der Bakterien des Wassers 64. 1893.

2. B. butyri fluorescens (Lafar). Arch. f. Hyg. **13**:1. 1891.

3. B. chromo-aromaticus (Galtier). Compt. Rend. **106**.

4. B. cyaneofluorescens (Zangemeister). Centralbl. f. Bakt. **18** : 34. 1895.

5. B. cyanogenus (Ehrenberg). Cf. Hueppe. Mitt. a. d. Kaiserl. Ges. **2** :—.

6. B. dentalis viridans (Miller). Die Mikroorganismen der Mundhöhle 316. [2d ed.]

7. B. erythrosporus (Eidam). Cf. Cohn and Miflet, Cohn's Beiträge 3 : 128.

8. B. fluorescens albus (Zimmermann). Die Bakterien unserer Trink- und Nutzwässer 18. Chemnitz, 1890.

9. B. fluorescens aureus (Zimmermann), *op. cit.* p. 14.

10. B. fluorescens capsulatus (Pottien). Zeitschr. f. Hyg. **22** : 140. 1896.

11. B. fluorescens convexus (Wright). Memoirs National Acad. Sciences **7** : —. 1895.

12. B. fluorescens crassus (Flügge). Die Mikroorganismen **2** : 294. [3d ed.]

13. B. fluorescens foliaceus (Wright), *loc. cit.*

14. B. fluorescens immobilis (Flügge), *loc. cit.*

15. B. fluorescens incognitus (Wright), *loc. cit.*

16. B. fluorescens liquefaciens (Flügge). Die Mikroorganismen 289. [2d ed.]

17. B. fluorescens longus (Zimmermann), *op. cit.* p. 20.

18. B. fluorescens mesentericus (Tartaroff). Die Dorpater Wasserbakterien. 1891.

19. B. fluorescens minutissimus (Unna and Tommasoli). Monatsch. f. prakt. Dermatol. **9**.

20. B. fluorescens mutabilis (Wright), *loc. cit.*

21. B. fluorescens nivalis (Schmolck). Centralbl. f. Bakt. **4** : 545. 1888.

22. B. fluorescens non-liquefaciens (Flügge). Die Mikroorganismen 293. [3d ed.]

23. B. fluorescens ovalis (Ravenel). Memoirs National Acad. Sciences **8** : —. 1896.

24. B. fluorescens putridus (Flügge). Die Mikroorganismen 288. [2d ed.]

25. B. fluorescens putridus colloides (Tartaroff), *loc. cit.*

26. B. fluorescens Schuylkilliensis (Wright), *loc. cit.*

27. B. fluorescens tenuis (Zimmermann), *op. cit.* p. 16.

28. B. fluorescens (Lepierre). Ann. de l'Institut Pasteur **9** : 643. 1895.

29. B. graveolens (Bordoni-Uffreduzzi). Fortschr. d. Med., 1886.

30. B. iris (Frick). Virchow's Archiv., **116** : 292. 1889.

31. B. leucæmiæ canis (Lucet). Baumgarten's Jahrb. **1891**: 319.

32. B. lupuliperda (Behrens) (cf. Lafar, Technical Mycology 166).

33. B. melochloros (Winkler and Schröter). Centralbl. f. Bakt. **9**: 700. 1891.

34. B. oogenes fluorescens (5 varieties) (Zörkendörfer). Arch. f. Hyg. **16**: 300. 1893.

35. B. proteus fluorescens (Jäger). Zeitschr. f. Hyg. **12**: 525. 1892.

36. B. pyocyaneus (Gessard). Thèse de Paris, 1882.

37. B. rugosus (Wright), *loc. cit.*

38. B. scissus (Frankland). Zeitschr. f. Hyg. **6**: 398. 1889.

39. B. smaragdinus-fœtidus (Reimann). Inaug. Diss., 1887.

40. B. striatus viridis (Ravenel), *loc. cit.*

41. B. virescens (Frick), *loc. cit.*

42. B. viridescens non-liquefaciens (Ravenel), *loc. cit.*

43. B. viridis (Lesage). Arch. de Physiol. **20**: 212. 1888

44. B. viridis pallescens (Frick), *loc. cit.*

45. B. viridans (Symmers). Brit. Med. Journ. **2**: 1252. 1891.

46. B. viscosus (Frankland), *op. cit.* p. 391.

47. Bacterium osteophilum (Billet). Bull. Scient. de la France et de la Belgique, 1890.

48. Diplococcus fluorescens fœtidus (Klamann). Allg. Med. Centralzeitung, **1887**: 1347.

49. Micrococcus fluorescens (Maggiora). Gior. Soc. Ital. d'Igiene **16**.

50. M. versicolor (Flügge). Die Mikroorganismen 177. [2d ed.]

ON THE LIFE-HISTORY OF LEMNA MINOR.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XII.

OTIS W. CALDWELL.

(WITH FIGURES 1–59)

THE greatly reduced sporophyte of the Lemnaceæ suggests the desirability of ascertaining to what extent these reductions have affected the gametophyte, and of looking more closely into the structures reported for the sporophyte. It is well known that flowering lemnas are seldom found, although during favorable seasons the vegetative plant is constantly seen in pools and slowly moving streams. Therefore, when in August 1897 an abundance of *Lemna minor* was found in flower it was decided to make an investigation of its morphology, in order to supplement previous work on the vegetative structures; to determine whether the usual sequences of monocotyledonous gametophytes and embryos were present; and to discover any suggestions of primitive or reduced conditions.

HISTORICAL.

The publications upon Lemnaceæ have been numerous, probably the most important being the monograph by Hegelmaier (**4**) in 1868, in which he gives the taxonomic features and also the general morphology in a way which is surprisingly accurate when one considers the condition of technique at that time. Another publication by Hegelmaier (**2**) deals entirely with the taxonomic features of the group; while in 1871 appeared a more detailed description of Spirodela (**6**) than that in the *Monograph*. Hegelmaier has also discussed the taxonomy of the group, based upon most recent knowledge (**12**). A similar work has been done for the American species by Thompson (**16**). Barbeck (**8**) has described germinating seeds of *L. minor*, and shows that the "plumule" emerges from between the folded edges of the cotyledon; that the embryonic root is small and quite transient; that at the base of the "plumule," which persists but a short time, there appear quite early the young pouches in which new plants are developed vegetatively. The writer falls into a common error when he speaks of this vegetative reproduction as "an interesting case of parthenogenesis."

With reference to the time and conditions of flowering and forming vegetative shoots, Guppy (**10**) thinks that were temperature and moisture constantly at the optimum point no flowers would be produced. He suggests, further, that the "winter buds" are formed by plants which have been weakened by flowering. This does not accord with the cases reported by various other observers, who state that they are formed without the intervention of flowers.

Hegelmaier dealt sufficiently with the morphology of the sporophyte to show that it is practically reduced to a structure for the work of photosyntax; that part of this structure is so arranged as to form pouches which protect the vegetative buds and flowers; and that abundant air spaces, which float the plant, are formed by the separation or the breaking down of cell walls. By means of numerous figures he showed the history of the vegetative structures of the sporophyte.

None of the above authors investigated the gametophytes.

THE SPOROPHYTE AND ITS VEGETATIVE MULTIPLICATION.

According to the usual interpretation, the adult plant (*fig. 1*)[1] is a flattened stem divided into three regions, the basal stalk region (*fig. 1, a*) which represents the first internode, the nodal region (*fig. 1, b*) from which arise new shoots and flowers, and above this another internodal region (*fig. 1*, *c*) which is entirely expanded as an organ of photosyntax. This function is also taken up by expanded portions of the node and basal internode, which are not distinguishable from the upper internode. In this upper region are three strands of conducting tissue, which in many cases were seen to proceed from the single vascular bundle that passes from the basal internode through the node. Frequently this presents the appearance of being one main axial bundle with a branch on each side. These conducting tissues extend almost to the margin of the frond,[2] passing in the upper

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[1] All drawings are from *Lemna minor*, and were made by means of Abbé camera. The magnifications given are those of the original drawings. Figs. 1–10 have been reduced in engraving to three-eighths and the remainder to one-half the original size. The stand and oculars used were by Reichert; the objectives were also by the same maker, except the $\frac{1}{12}$, an oil-immersion lens by Bausch and Lomb. The combinations used were as follows: × 35 (fig. 8), ocular 160^{mm}; objective 3; × 45 (figs.

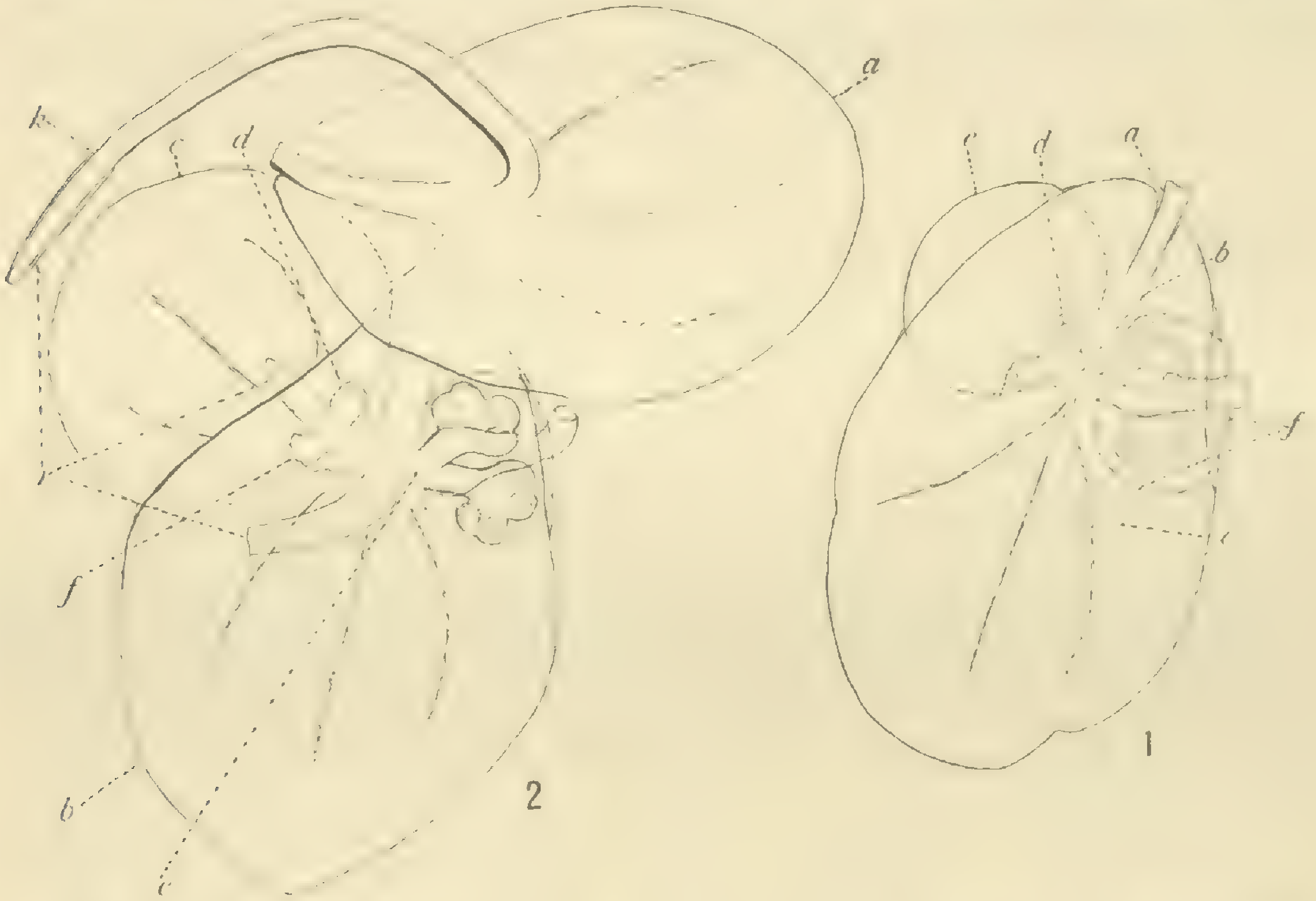


FIG. 1. **Diagram of an adult plant. At the right of the main axis is a flower** with its spathe, *f*, and carpel extending through the pouch opening. At the left, a young plant, *c*, bearing younger plant, *d*, opposite which is a young flower. *a*, basal **internode.** ***b*, node.** × 45.

FIG. 2. Four generations of plants, *a*, *b*, *c*, *d*, respectively. *e*, old flower. *f*, young flower. *r*, root. *k*, root cap. × 45.

1, 2), oc. 2, obj. 3; × **73** (figs. 9, 12), oc. 4, obj. 3; × **260** (fig. 10), oc. 160mm, obj. 7; × **520** (fig. 11), oc. 160mm, obj. 1/12; × **760** (figs. 4, 5, 6, 57, 59), oc. 4, obj. 7; × **890** (figs. 14–16, 42), oc. 2, obj. 1/12; × **1375** (figs. 3, 7, 13, 17–37, 40, 41, 43–56, 58), oc. 4, obj. 1/12; × **2400** (figs. 31, 32, 38, 39), oc. 12, obj. 1/12.

[2] The term "frond" is usually applied to this entire plant. The use of the term

internode about midway between the dorsal and ventral surfaces. They are almost devoid of tracheary tissue, there being in the basal half of the strand a single row of very small tracheids, as shown by Hegelmaier. Throughout the entire strand there are two or three layers of phloem cells which are densely filled with protoplasm. The apical half of the bundle is composed entirely of such cells. It is quite probable that no tracheary tissue is needed, since the cells of the plant are all in direct contact with the water or nearly so.

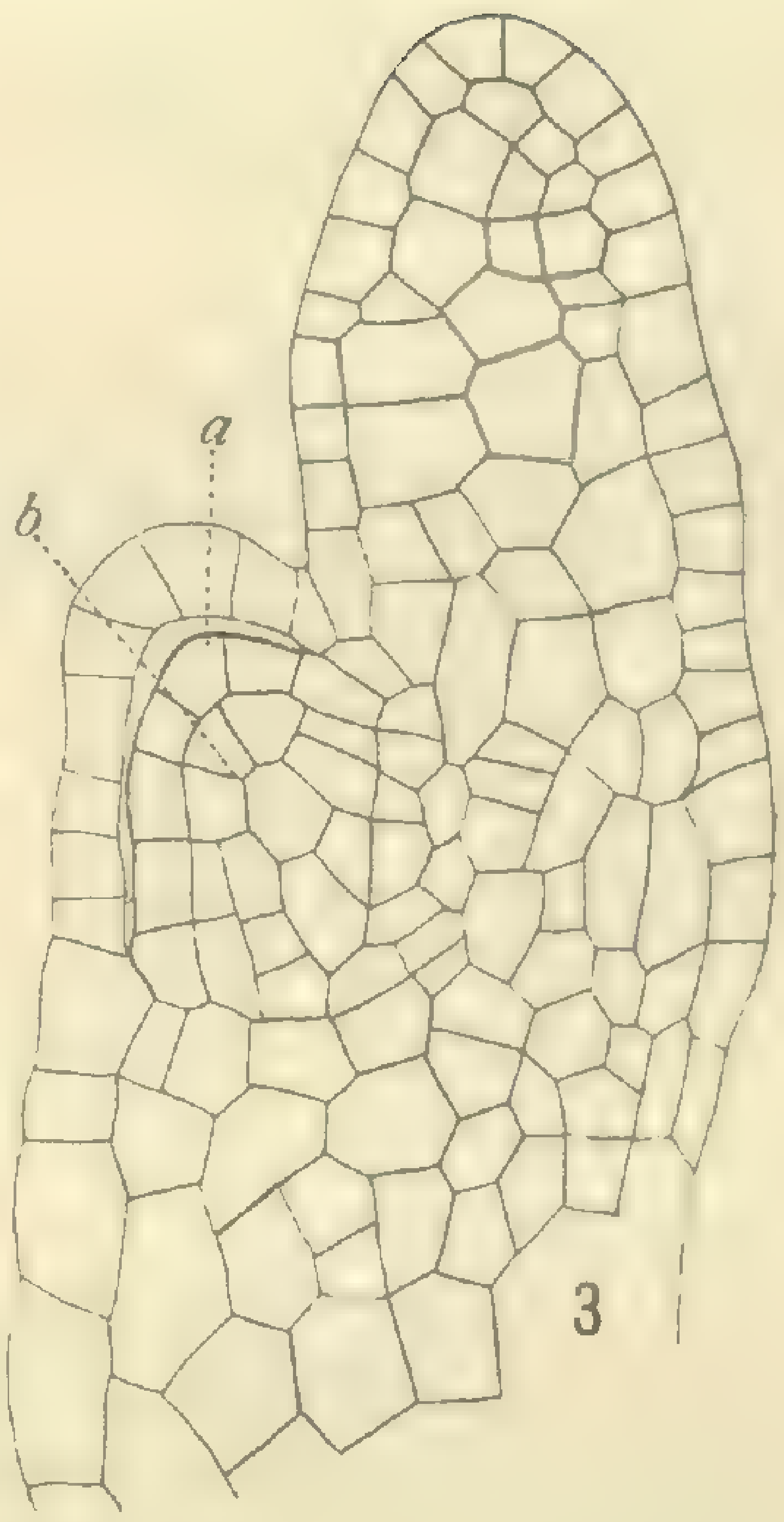
As described by Hegelmaier, the pouches in which the vegetative shoots appear are formed by outgrowths from the upper and lower surfaces of the parent plant. In an early stage the young plant appears in the bottom of the pouch as a very short-stalked outgrowth from the node (*fig. 1, d*), the mother plant in this case being about half grown and extending from the pouch of the plant *b*. My observations agree with those of Hegelmaier in that two young plants never appear at the same time on one side of a parent plant. While the bud is quite young its cells divide very rapidly, but soon cease such rapid multiplication and greatly increase in size. As they enlarge, the walls of the cells divide to form the air spaces, the latter being separated from one another by a single layer of cells. I was not able to find cases in which air spaces were formed by the breaking down of cells, as described by Hegelmaier. There are two general regions of intercellular spaces, the dorsal and the ventral, that are incompletely separated by a region of small cells through which the conducting strands pass. The cells about the air spaces contain very large chloroplasts which, as has been frequently mentioned, have unusual freedom of movement.

The rapidity of this vegetative multiplication is remarkable. At the time when a young plant extends half the length of the pouch in which it grows, it has itself developed pouches and begun a new plant. It is quite common to see attached to one

is unfortunate, since it was originally applied to the aerial part of the ordinary fern, which is morphologically quite different from the lemna plant. In the absence of a better term, and since I do not now wish to introduce a new one, the term "frond" may be used at times in this paper.

another four to six generations of plants, only one of which is fully formed. In *fig. 2* there are shown four plants, two of which (*a* and *b*) are fully formed, one (*c*) is about half the adult size, and one (*d*) is a very young plant. With high magnification it would be possible to distinguish the beginning of a yet younger plant from *d*. The plants *b* and *c* each bear flowers (*e* and *f* respectively). *Fig. 1* is from the ventral side, so that the roots (*r*) of the three older plants are shown.

The root arises from the lower side of



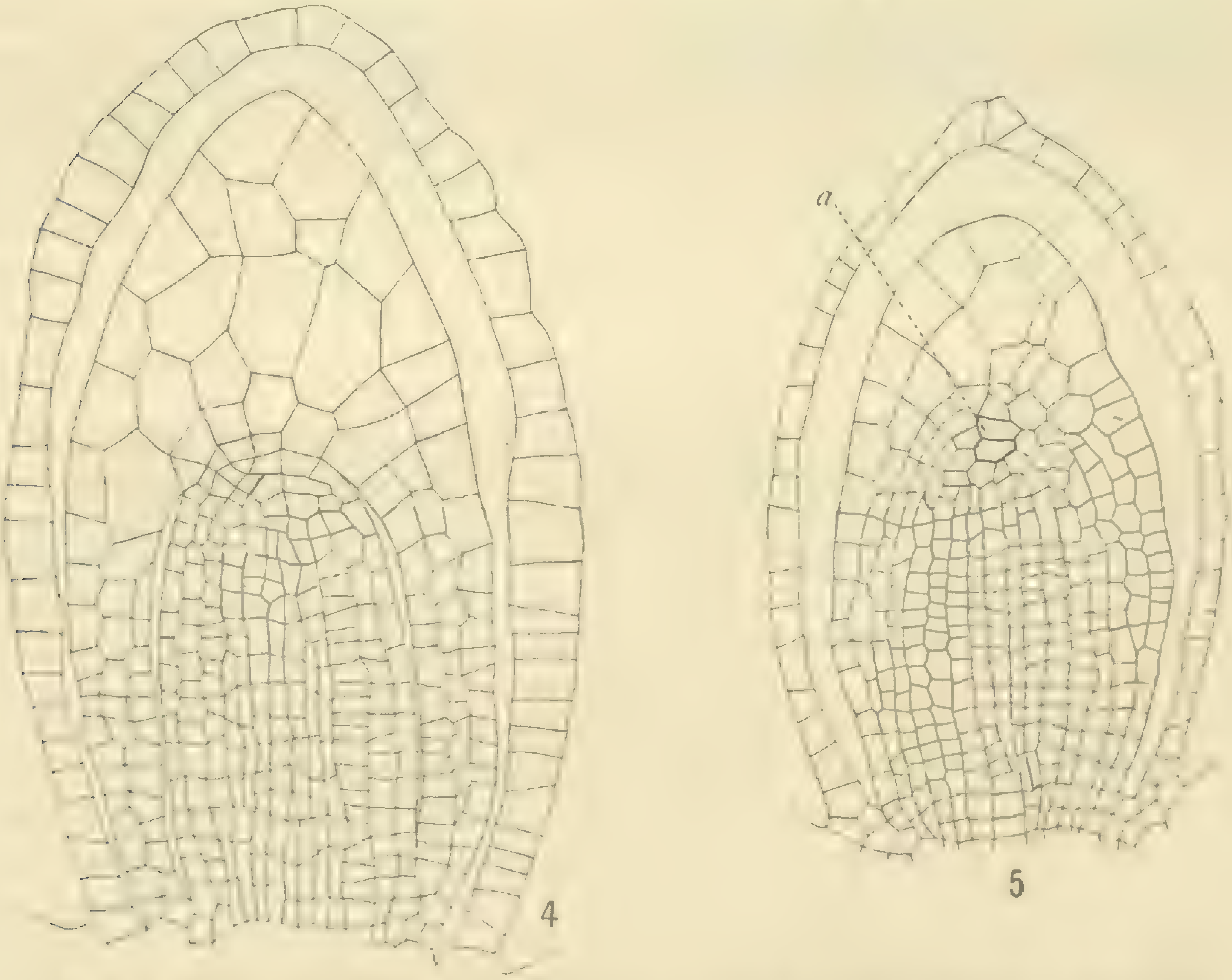


FIG. 3. Young frond sectioned transversely to flat surface, showing young root below. *a*, root cap. *b*, meristem region. × 1375.

FIGS. 4, 5. Young roots, each showing temporary epidermal sheath, root cap, and the main body of the root. *a*, meristem cells. × 760.

the node. It may be distinguished quite early, appearing as a papilla formed by rapidly growing hypodermal cells (*fig. 3*). This figure represents a median longitudinal section cut transversely to the surface of the young frond. The epidermal cells divide as they are forced out, forming a temporary root sheath. This sheath may persist for some time (*figs. 4, 5, 6*) but is finally broken and decays.

Very early in the development of the root the layer of cells is seen (*fig. 3, a*) that develops into the root cap. This layer continues to thicken by additions from the meristem region below (*fig. 3, b*). The number of cells constituting this meristem region is unusually small (*figs. 5, a, 6, a*), in some cases consisting apparently of but one cell. The walls of these cells are drawn heavier than those of adjacent ones, simply to point them out. Miss Amelia McMinn (11) states definitely that this is an apical cell, and such may be true as to position, but probably not as to morphological character. I find no such break in the continuity of cells at the root tip as shown by Hegelmaier in *pl. 10, figs. 8, 9* of his *Monograph.*

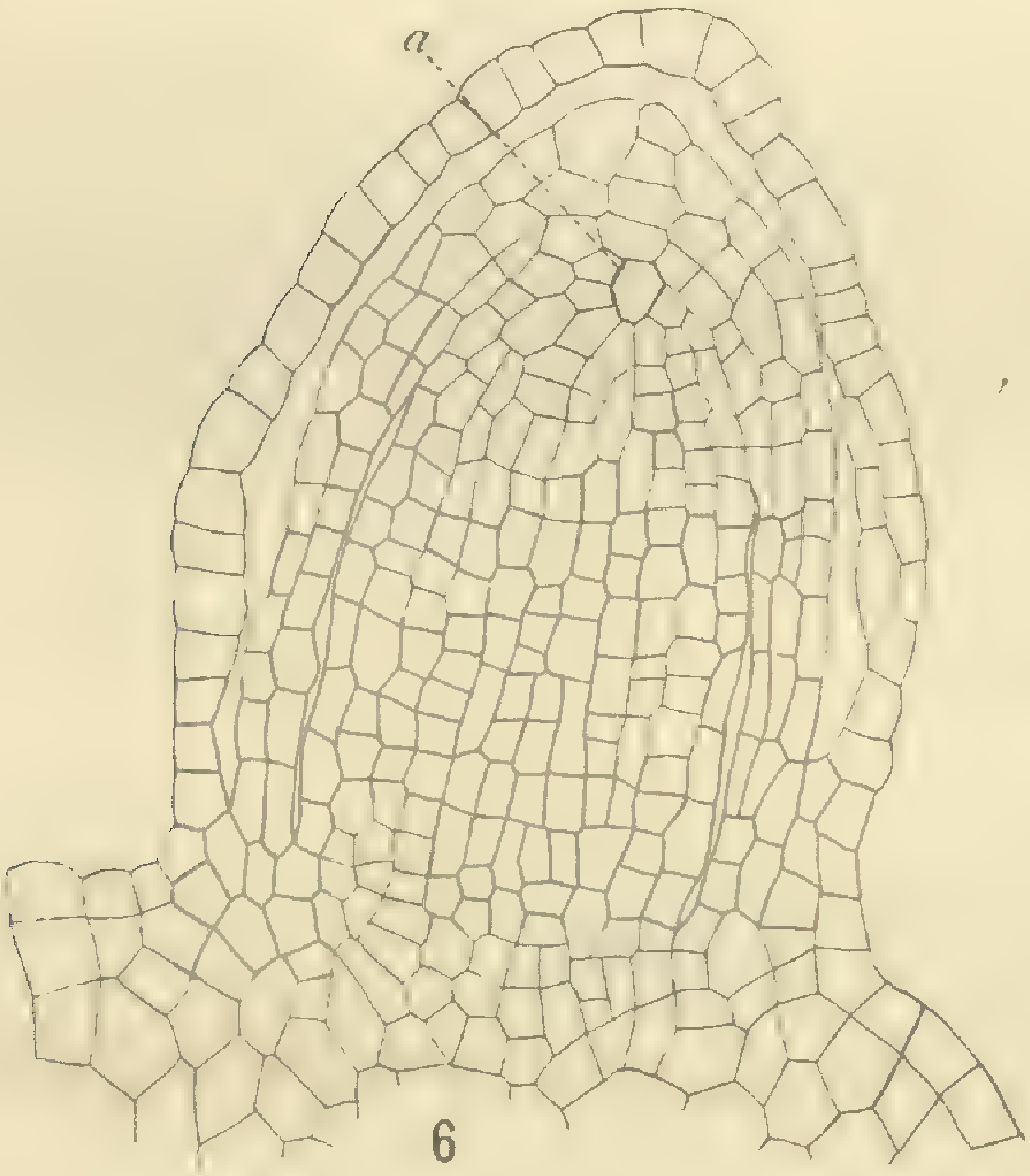


FIG. 6. Young roots, each showing temporary epidermal sheath, root cap, and the main body of the root. *a*, meristem cell. × 760.

The root cap is at first united with the main body of the root (*fig. 5*), but back of the growing point it may be seen quite early to become free, and before the root has attained any considerable length the cap has become separated from a region opposite to the meristem down to the base of the root (*figs. 4, 6*). In the older roots the cap is found still attached to the growing point, and, although it has become free at the lower end, it remains closely appressed to the root (*fig. 2, k*). In *fig. 7* is shown a fairly young root in cross section, in which appears the temporary root sheath (*a*), the root cap (*b*), and the main body of the root (*c*), in which the axial region (*d*) is more or less separated from the cortical region by air spaces. The cells of this axial region, which are three or four times the length of the cortical cells and not so wide, are arranged with diagrammatic regularity about a central cell. The outer cells of this cylinder are seen to be dividing by periclinal walls. This axial cylinder is the representative of the conducting system of the root. The structure of the root is not unlike that of other water plants, *e. g.*, naiads and potamogetons.

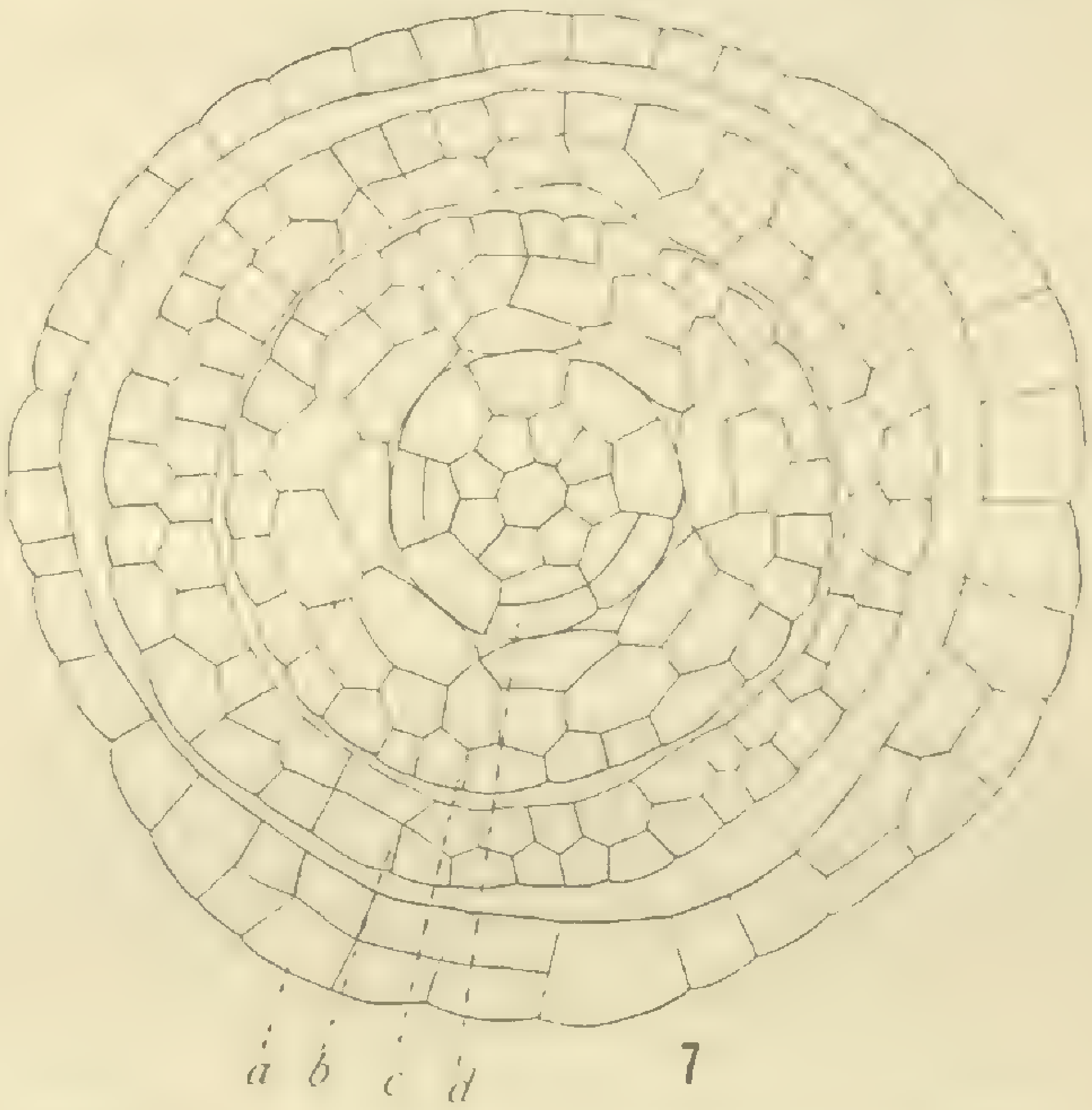


FIG. 7. Cross section of young root. *a*, epidermal sheath. *b*, root cap. *c*, body of root. *d*, axial cylinder. × 1375.

My own observations and those of others have led me to suggest that the lemna plant is not necessarily a flattened stem, in which the basal internode represents the original stem of the plant; or that it is a leaf with the power of producing new leaves from the specialized region known as the node; or that the basal region represents stem and the upper internode leaf; but rather that the entire structure is a shoot in which the basal and nodal regions are differentiated to serve special functions, and the upper internodes are entirely undifferentiated. The single conducting strand of the basal internode passes through the node and into the upper internode, where it may give off two branches, as in *L. minor*, or more, as in other species. It may also branch from the node into the new plants and the floral organs. It appears that this strand is the axial bundle of the entire shoot, and that the apical region represents the undifferentiated condition from which the basal internode and node have become specialized.

With such an interpretation as this, the discussions whether this is flattened stem or leaf have no morphological basis, and it would be more appropriate to speak of the undifferentiated shoot as a thalloid structure than as a stem or leaf or frond.

ORGANOGENY OF THE FLOWER.

Plants in the flowering condition usually have well developed pouches at each side of the node. In one of these a young plant appears, while a flower develops in the other. This flower is often accompanied by a young plant, which when present appears just outside of the bottom of the spathe. Quite frequently it grows rapidly, and takes the place of the flower, though in many cases the parts of the flower are seen to have broken down before they were encroached upon, thereby making it clear that some other influence than pressure from the young bud injured the flower. Flowers may reach maturity, however, when young buds are growing at the side of the spathe.

In *fig. 8* is shown the diagram of a section made transverse to the surface of the plant, passing through the node in such direction that in one pouch the carpel (*a*) and stalk of one stamen (*b*) of an old flower are shown; while in the opposite pouch is a young plant (*c*) which bears a young flower (*d*). At

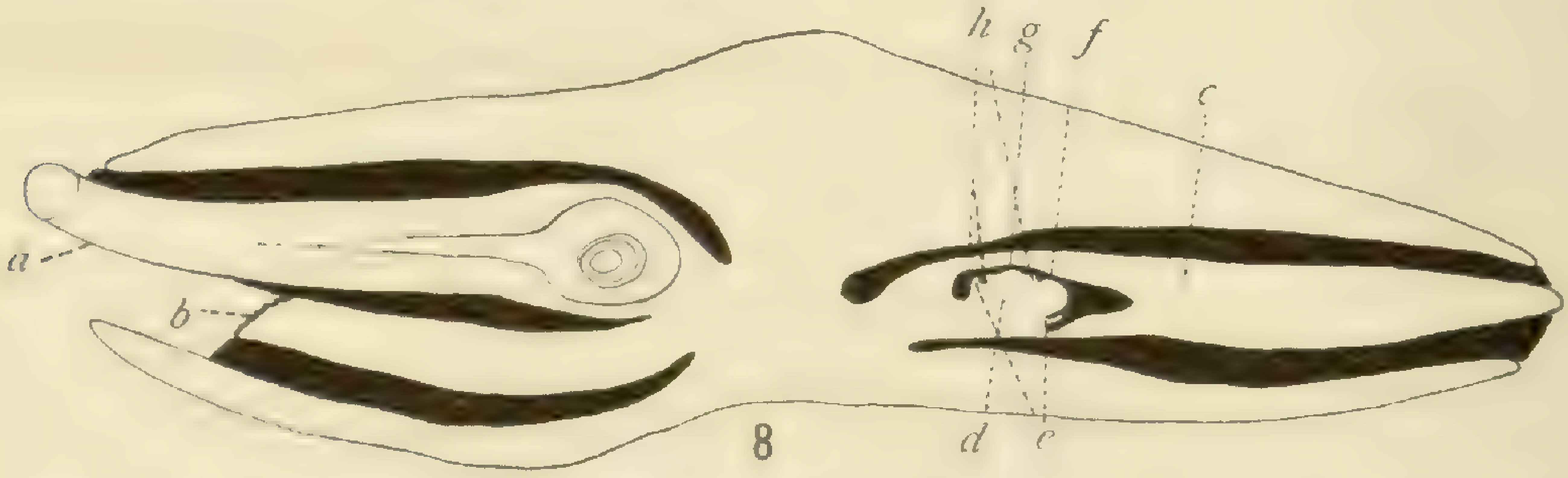
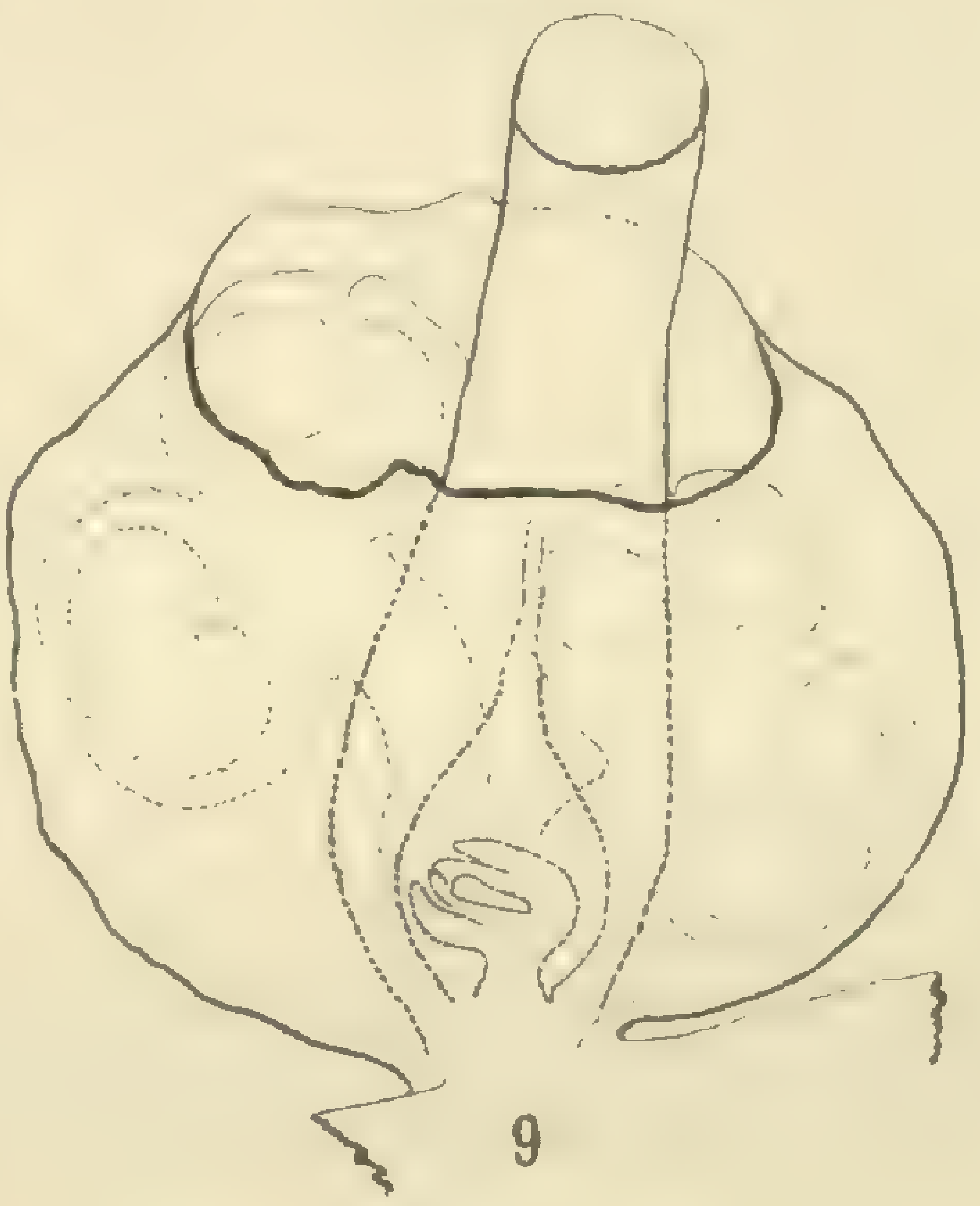


FIG. 8. Diagram of cross section of plant showing an old flower in one pouch and a young frond bearing a young flower in the other. × 35.

the outside of this flower is the beginning of the spathe (*e*), which grows up about the other floral organs. This spathe when fully formed is usually one cell in thickness, though rarely it is two-celled at the base. It grows rapidly and soon extends beyond the edge of the frond (*fig. 1, f*), becoming the only means of detecting the presence of flowers when one is unaided by a magnifying glass. In *fig. 9* the fully formed spathe is shown as it surrounds the carpel and stamens.



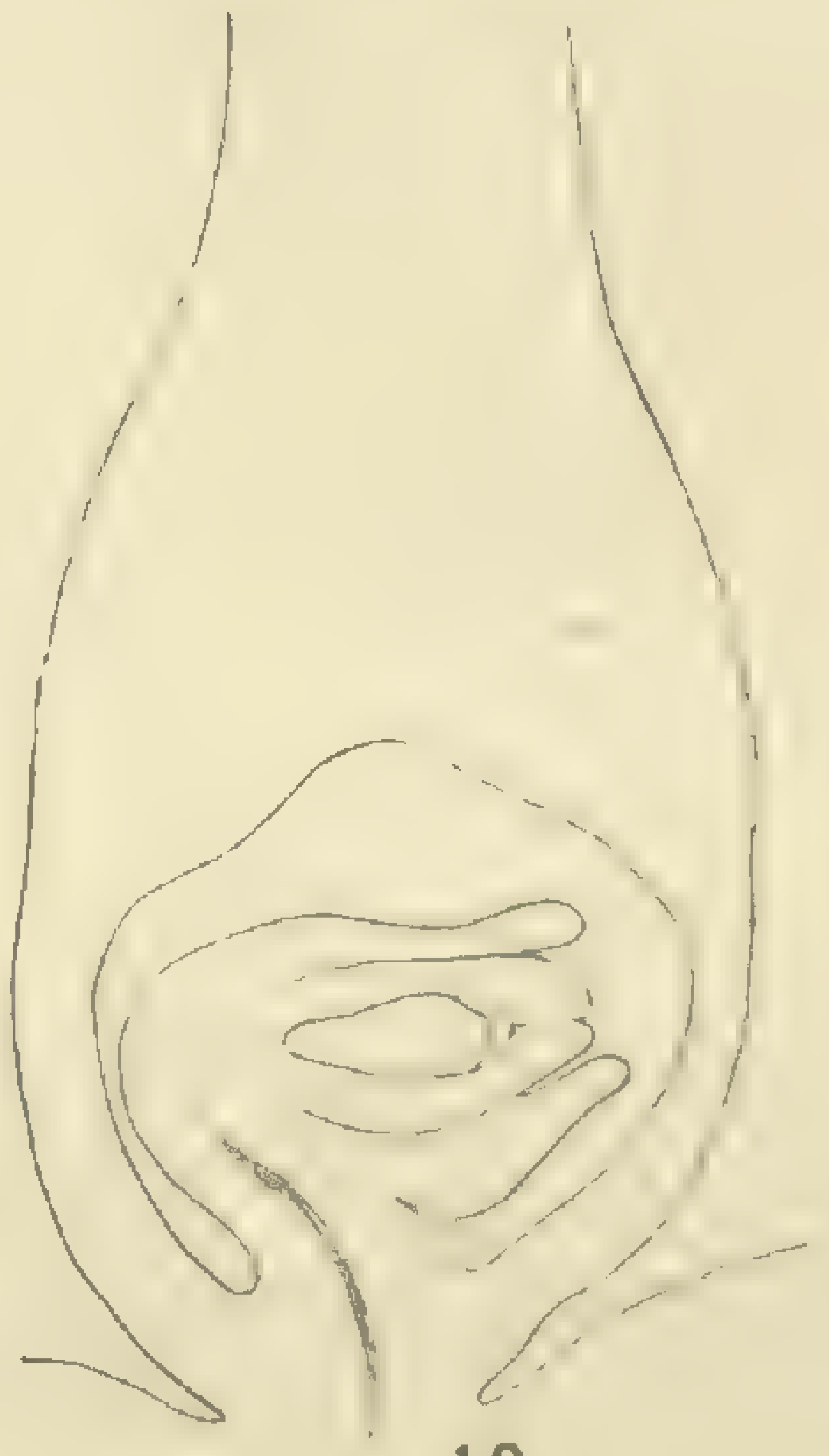
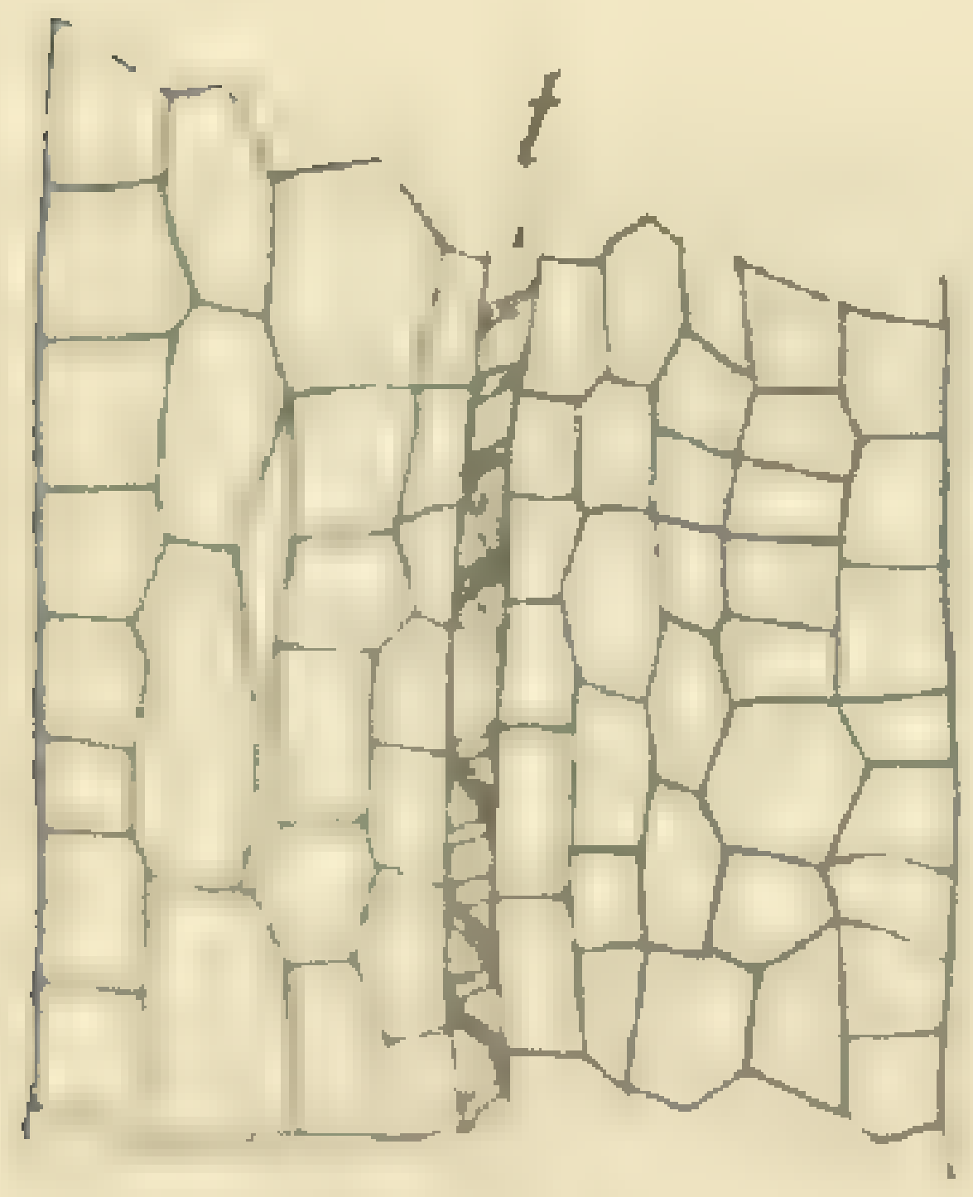


FIG. 9. Flower-spathe enclosing carpel and two stamens; ovule seen in carpel. × 73.

FIG. 10. Carpel with ovule; stigma region of carpel not shown. × 260.

The stamens appear at first as one small protuberance extending in the plane of the surface of the frond (*fig. 8*). As this projection becomes longer it branches, each branch later becoming one stamen. One of these branches is always less prominent and less advanced than the other. In adult stamens the single row of tracheæ (*fig. 11*) of each filament is seen to have originated from a common bundle at the region of branching (*fig. 12*). When the stamens are mature the anthers, the loculi of which lie in one plane, are pushed out beyond the margin of the spathe by the rapid elongation of the filament.



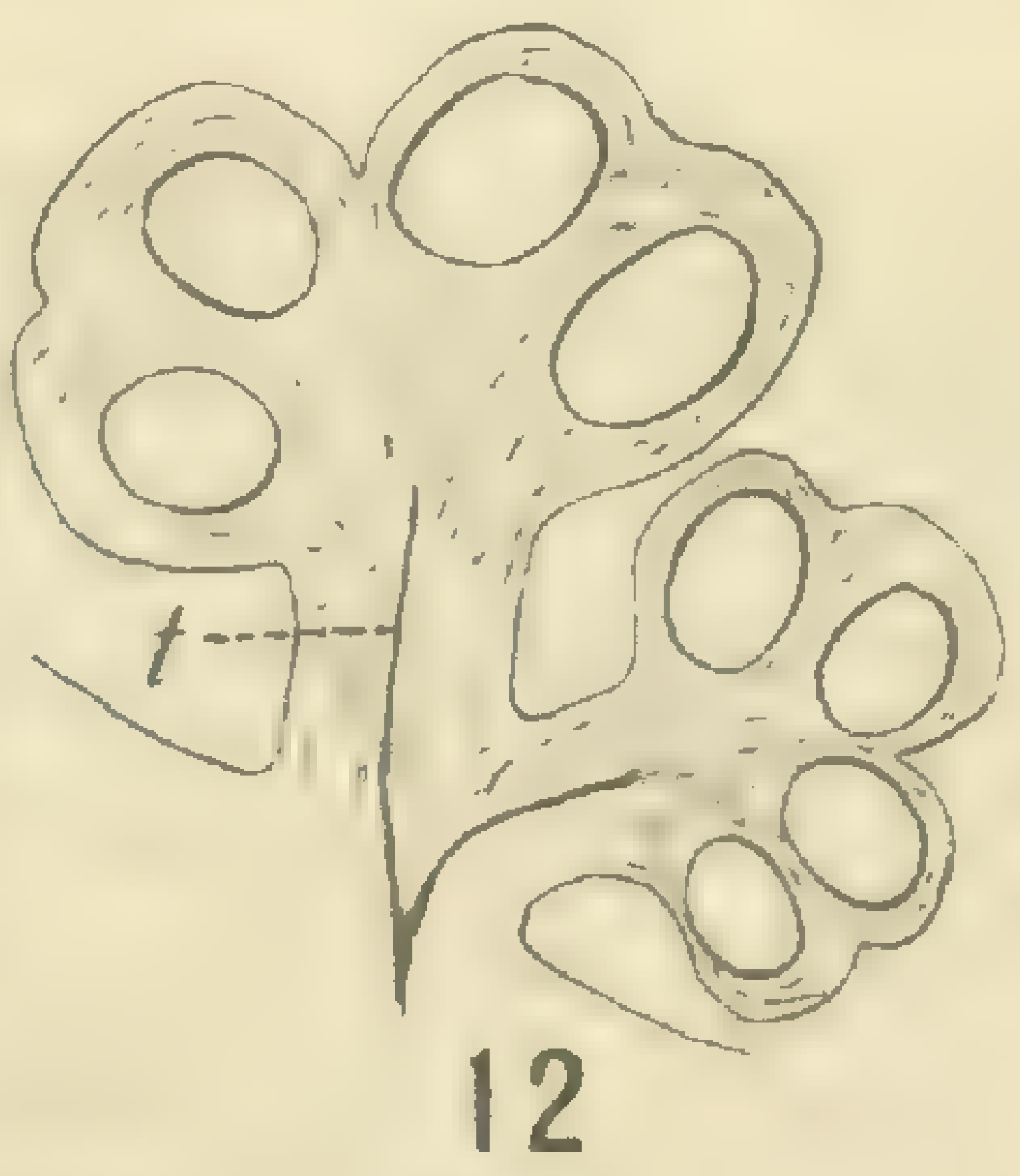


FIG. 11. Longitudinal section of part of filament, showing single row of tracheæ, *t*. × 520.

FIG. 12. The stamens of one flower. *t*, vascular bundle. × 73.

The carpel arises from the same general region with the stamens. In *figs. 8* and *9* is seen the nucellus, the projections on either side of which are to form the walls of the carpel. These projections grow rapidly, soon extending beyond the nucellus. A fully formed flower is shown in *fig. 9*, in which the carpel extends beyond the spathe and encloses the single half-anatropous ovule. Further discussion of the development of the carpel and ovule will be taken up in connection with the megaspore.

The homologies of the floral arrangement are very perplexing. It may be true, as given in the usual accounts, that there are here two flowers, one carpellate, the other staminate, enclosed in a common spathe. I can see no good reason for thus separating the carpel and the stamens. If the conditions are taken as they present themselves, it would seem as if this might be a single flower, with its parts probably spirally arranged, and enclosed within a spathe. If we are to take as evidence the supposed relatives of the Lemnaceæ, the aroids, we must recognize that the former are represented by forms so greatly reduced that we are safe in saying but little as to the kind of aroids from which they have been derived.

DEVELOPMENT OF THE MICROSPORES.

Young stamens which are not yet represented by distinct branches show a group of archesporial cells[3] immediately beneath the epidermis. One such stamen is shown in *fig. 13*. The two stamens at this time appear as obtuse outgrowths upon a very short stalk, the two together presenting the appearance of a single stamen in which two archesporial masses may be seen (*fig. 14*). Later stages show clearly that these are not two archesporial masses of one stamen, since as the anther grows each mass of archesporial tissue broadens and deepens and becomes divided by a plate of sterile cells which cease to take the characteristic stain of archesporial tissue. This is shown in the left of the two stamens in *fig. 14*. After a short time each of these groups of archesporial cells is divided in the same way, thus producing the archesporial masses of the four loculi of the stamen. This condition is shown in the older stamen of *fig. 15*, while the younger stamen of this figure has its archesporium divided into two masses.

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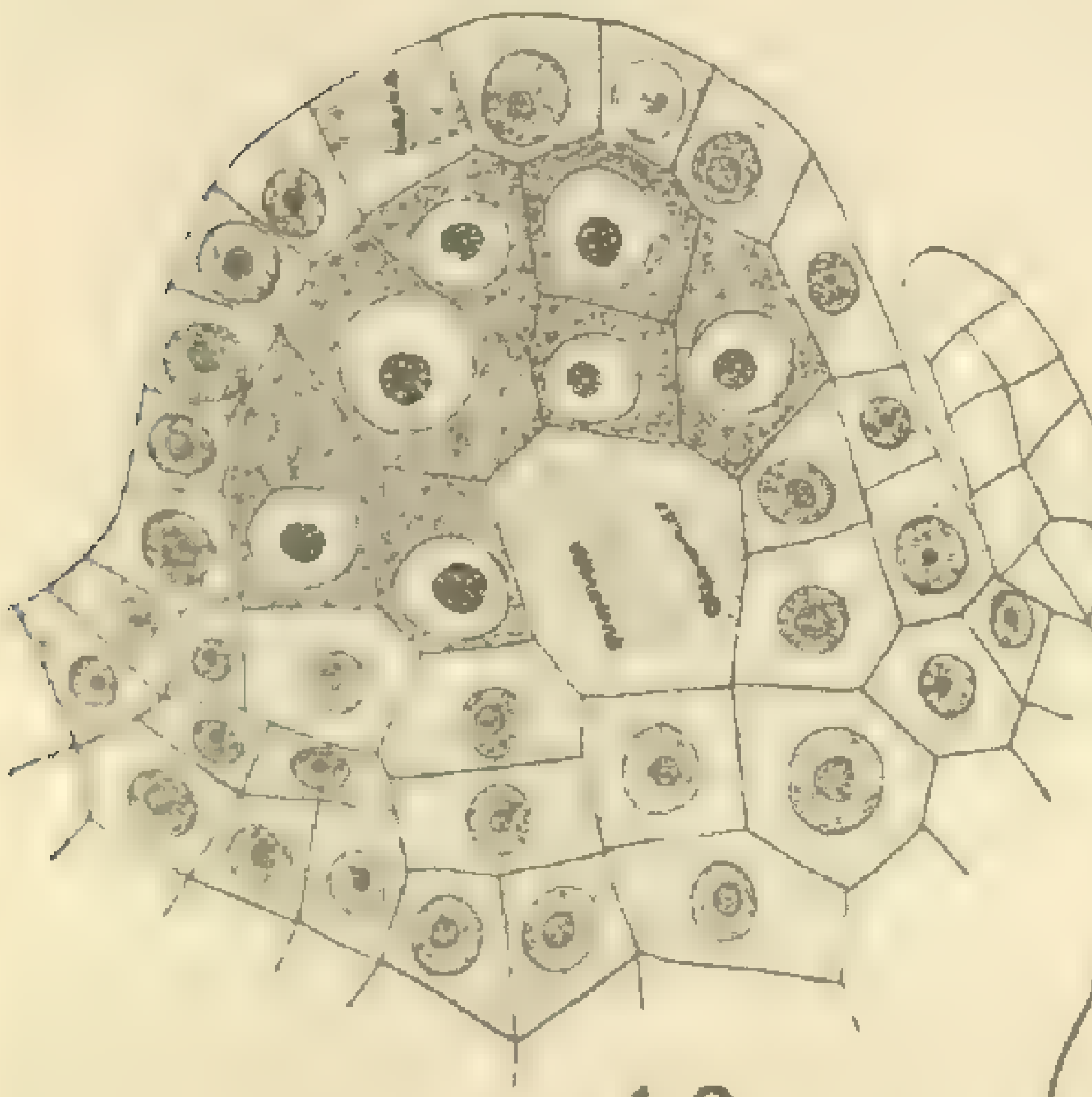
[3] While there may be some question as to just what cells should be called archesporial, for convenience I shall use the term in describing the cells of this region until they become clearly separated into sporogenous cells and those of the tapetal row.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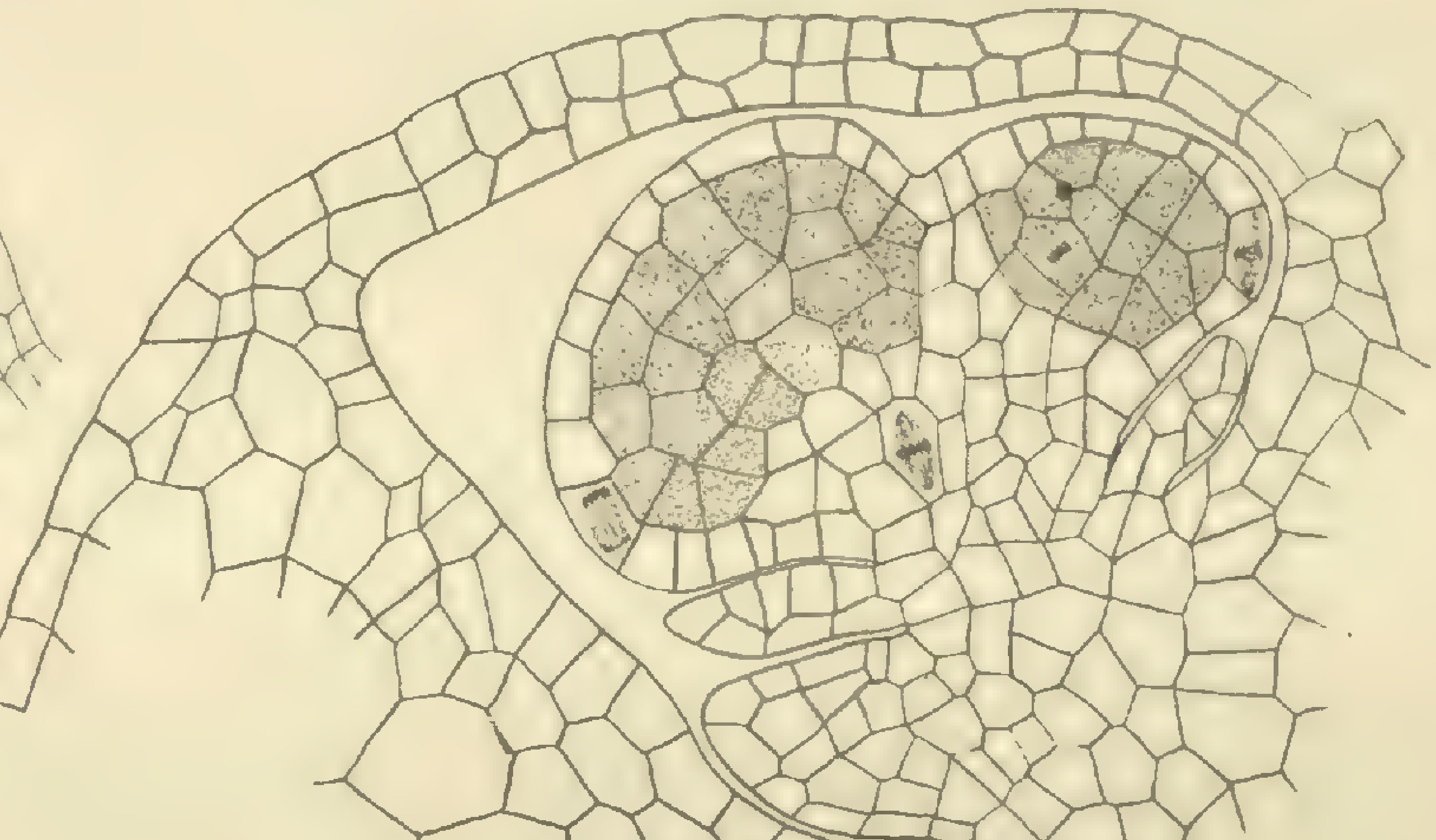
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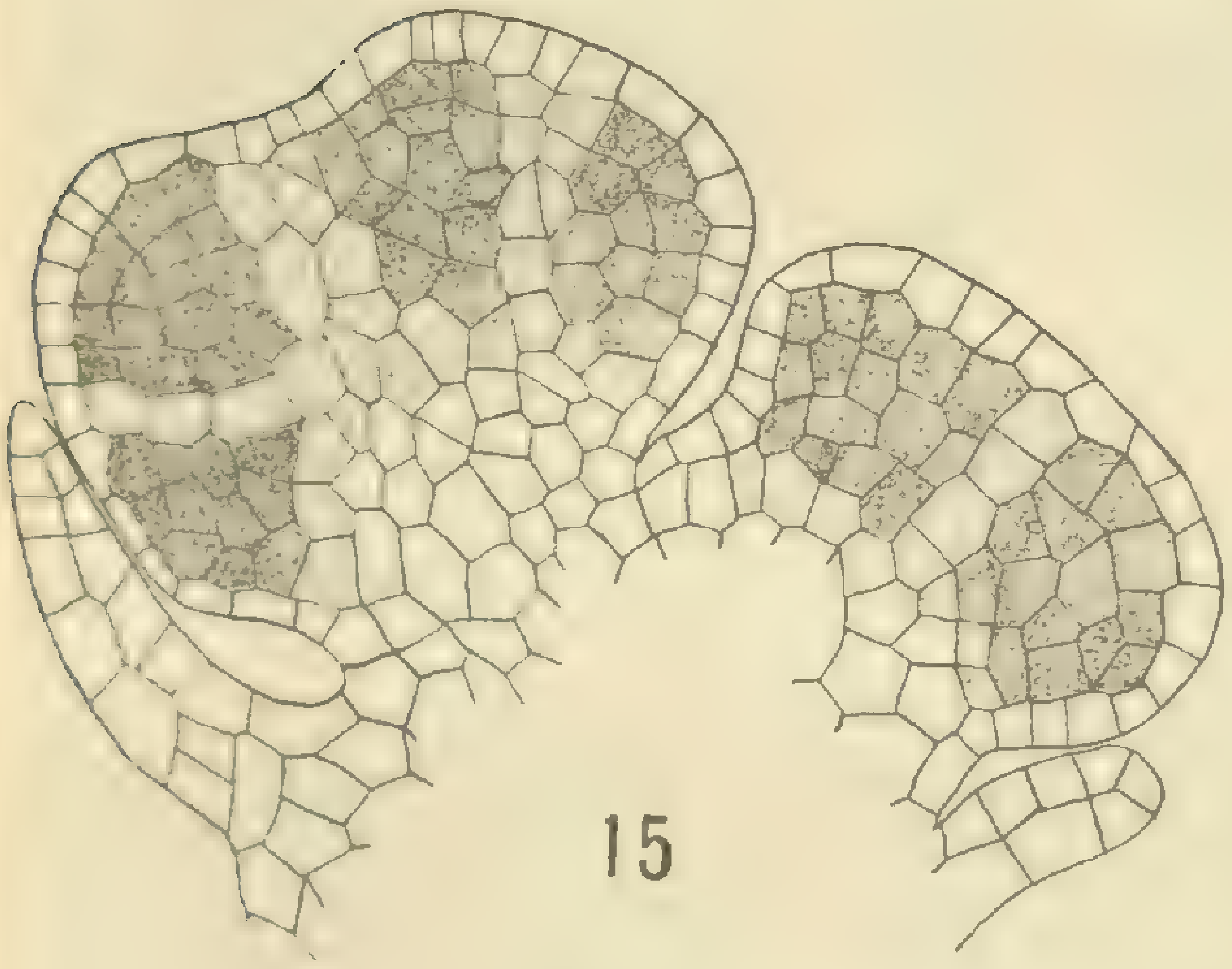
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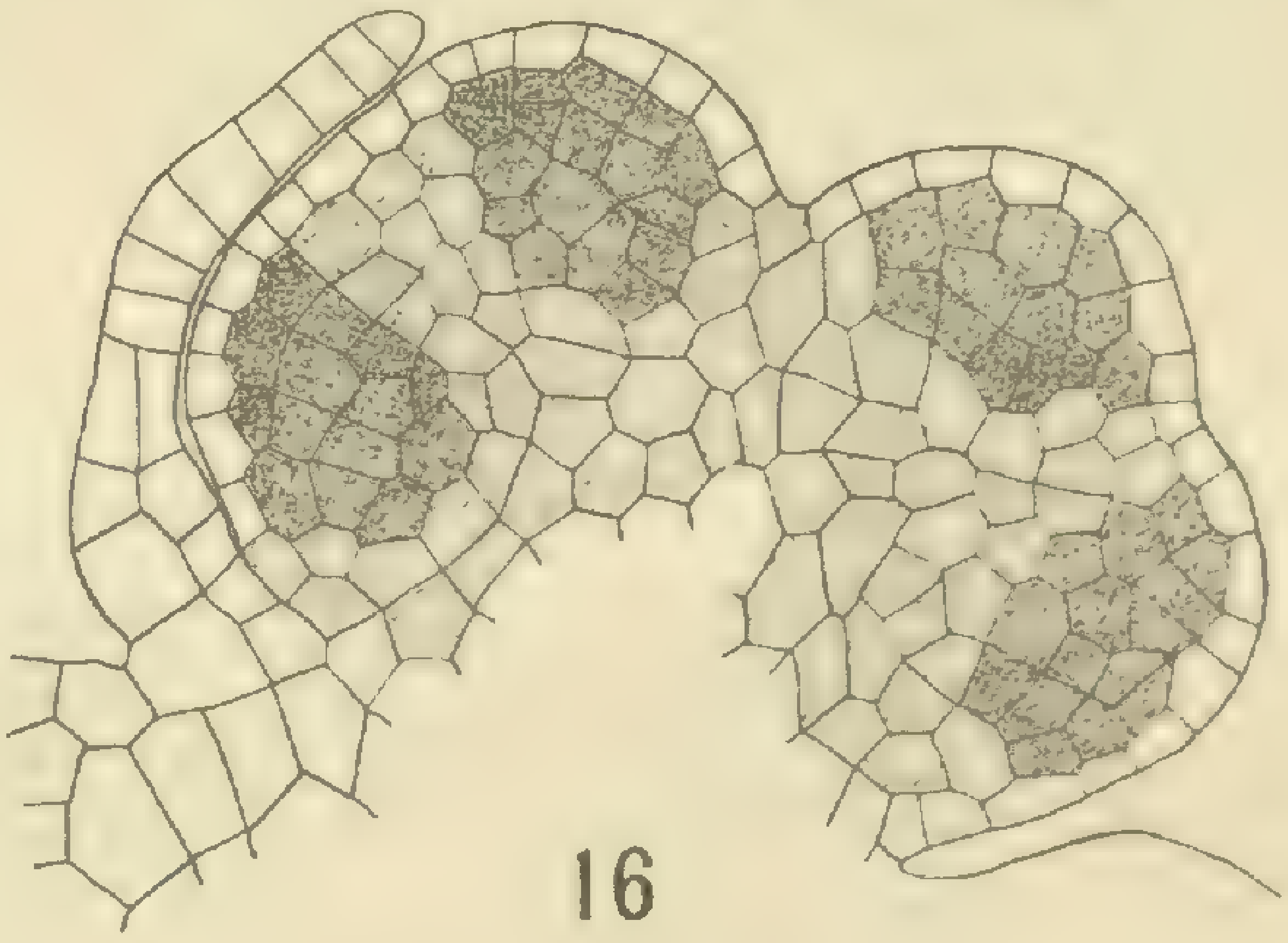
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FIG. 13. Young stamen with archesporial tissue. × 1375.

FIG. 14. Two young stamens; in one the archesporial tissue is becoming divided by a sterile plate; beginning of the spathe is seen. × 890.

FIG. 15. Same as *fig. 14* but more advanced. × 890.

FIG. 16. One stamen showing the four loculi well separated. × 890.

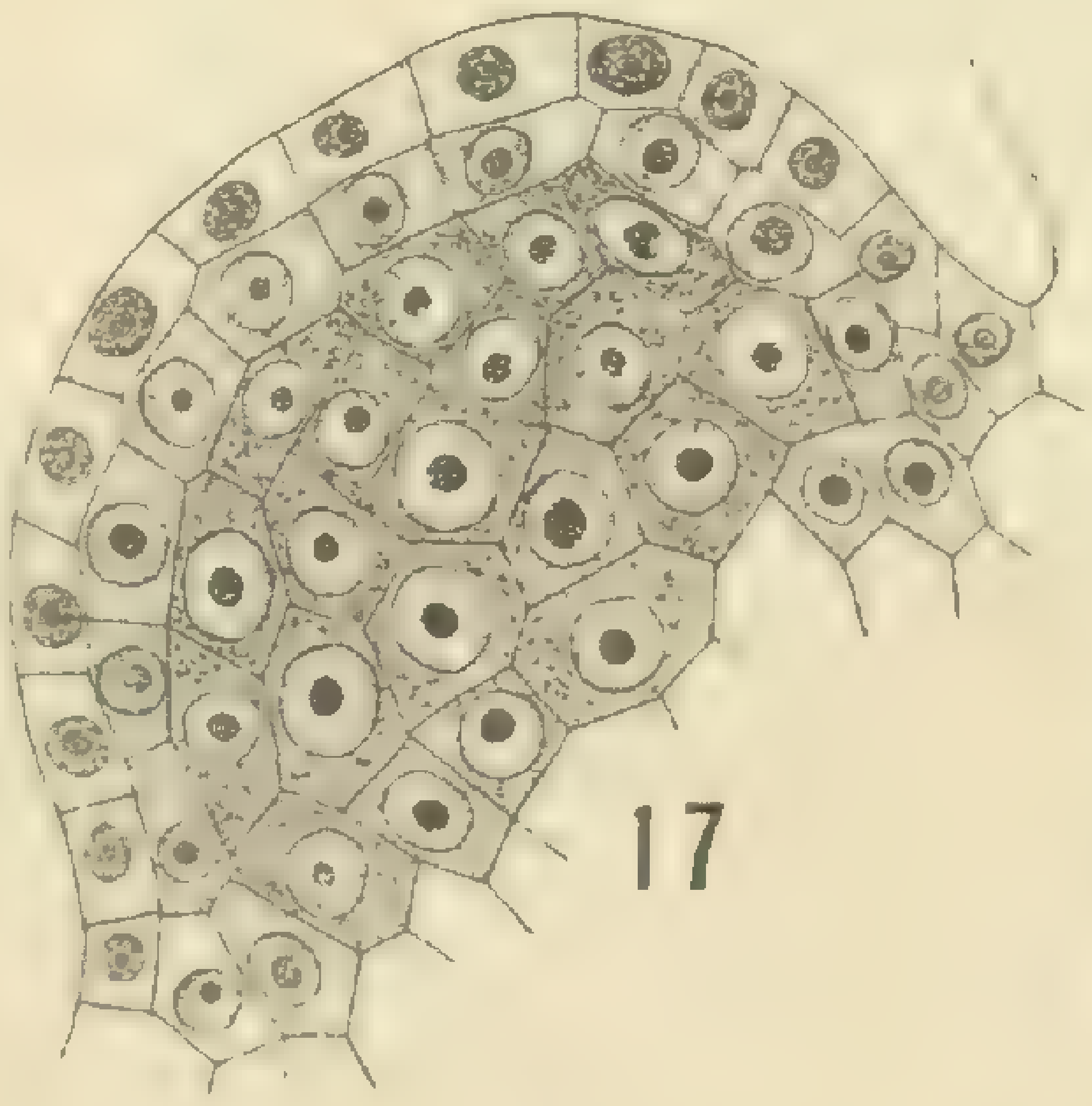
In an examination of later stages in the development of these tissues it will be seen that the separating region continues to develop new cells until the usual amount of sterile tissue between the fully formed loculi may be seen (*fig. 16*). In the youngest anthers in which archesporial tissue could be detected, no indication of the exact region to become sterilized could be made out, since all the cells stain alike. However, one may soon distinguish the larger, more lightly stained, and less rapidly dividing cells which are to form the sterile plate. In *Naias flexilis* Campbell (14) observed that but one archesporial mass is formed in each anther; that this multiplies its cells for a considerable time before there occurs any differentiation into tapetal and sporogenous regions; and that "even in later stages the boundary between the sporogenous cells and those lying outside is not always perfectly clear." But in this mass of archesporial tissue no sterilized separating regions were formed, the entire mass forming a unilocular sporangium.

Such conditions suggest certain pteridophytes, where the sporangia are developed in a manner not unlike those of *L. minor.* In Isoetes we have an archesporial mass which, after having grown until it consists of a large number of cells, develops plates of sterile cells, the trabeculæ, which separate groups of sporogenous cells more or less completely from one another. In Isoetes the number and arrangement of these groups of sporogenous cells are irregular, while in *L. minor* they are regular; but in other respects the two present many points in common. The origin of the archesporial tissue seems to be the same, since in each it originates as a hypodermal layer; in behavior it is essentially the same, since in both it divides rapidly, forming a mass of cells, some of which become sterilized as plates which separate groups of sporogenous cells; and in each the tapetum is formed after these sterilized plates are completed.

If my observations and interpretations are correct, and if the spore bearing region of Isoetes is a single sporangium, the four groups of sporogenous cells of one anther of *L. minor* must be the same. Whether in angiosperms other than *L. minor* it can be shown that each loculus of the anther is not a real sporangium, as given in current accounts, but rather that two or four loculi of one anther are together the sporangium, must be determined by further work. The question certainly deserves careful investigation.

Following the stage last cited (*fig. 16*), the archesporial cells continue to divide until two or three times the number of cells are developed. At about this time there appears immediately beneath the epidermis a layer of cells which by their reactions to stains are clearly differentiated from the cells beneath (*fig. 17*). Their nuclei stain more deeply, and the cytoplasm less deeply than the nuclei and cytoplasm of the cells beneath. This is the primary tapetal layer, while the cells below are the sporogenous cells, or probably by this time they are the microspore mother cells. The primary tapetal layer, therefore, is not cut off from the archesporium immediately following the appearance of the latter as a primitive layer, but after considerable masses of archesporial tissue are formed and segregated. It is not a primary but a secondary differentiation.

Between the mother cells and the epidermis in older loculi there are three or four layers of tapetal cells (*fig. 18*). The number of these layers is not necessarily regular for all the parts of a given loculus, as is shown in the figure just cited. I have not been able to decide definitely upon the origin of the tapetum. In some preparations the relative positions of the cells indicate that the tapetum has been cut off from the sporogenous cells, while in other cases it seems equally clear that it has come from the wall layers. It will be borne in mind that in the sporangia of the pteridophytes the tapetum is cut off from the sporogenous



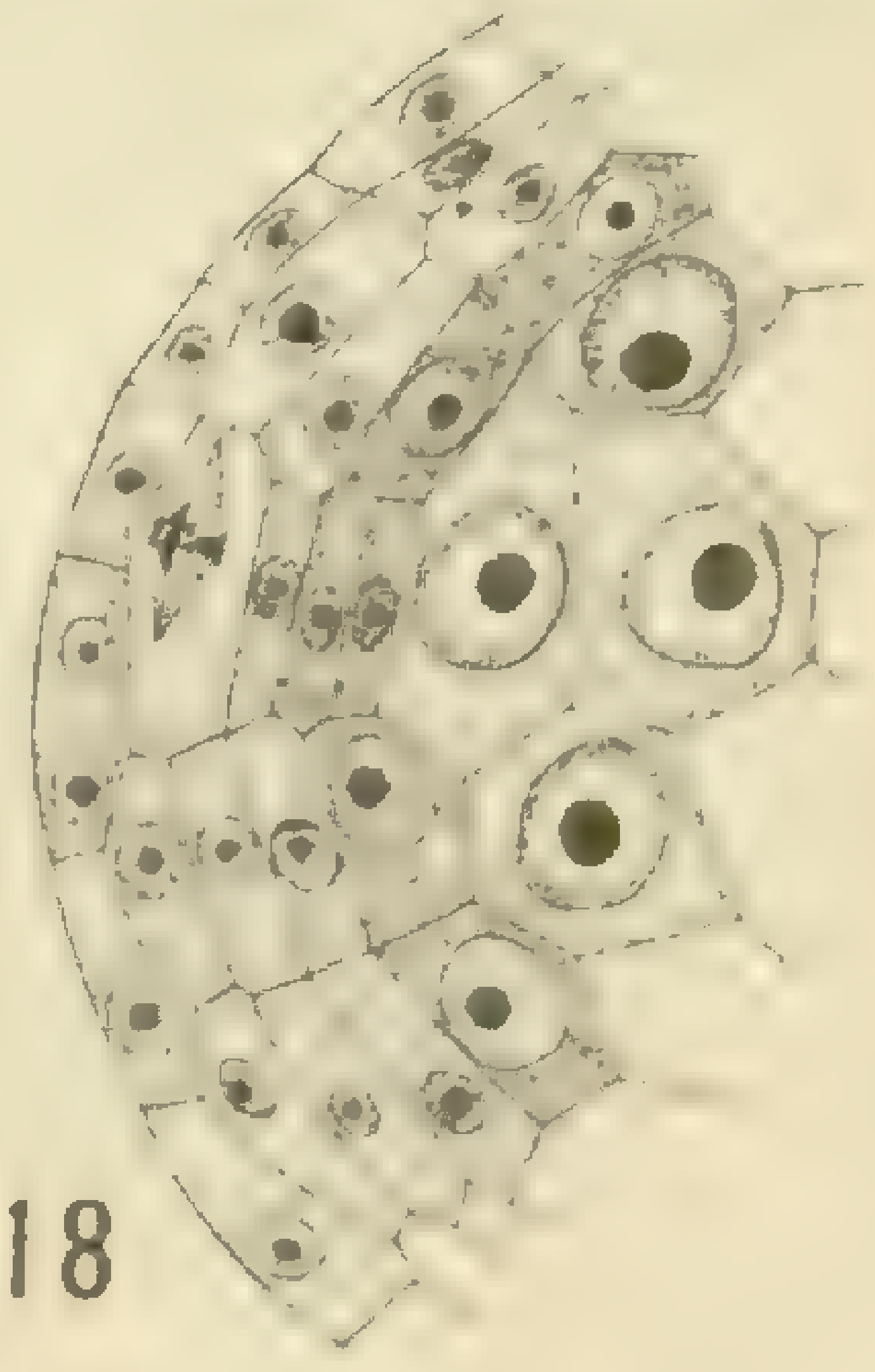
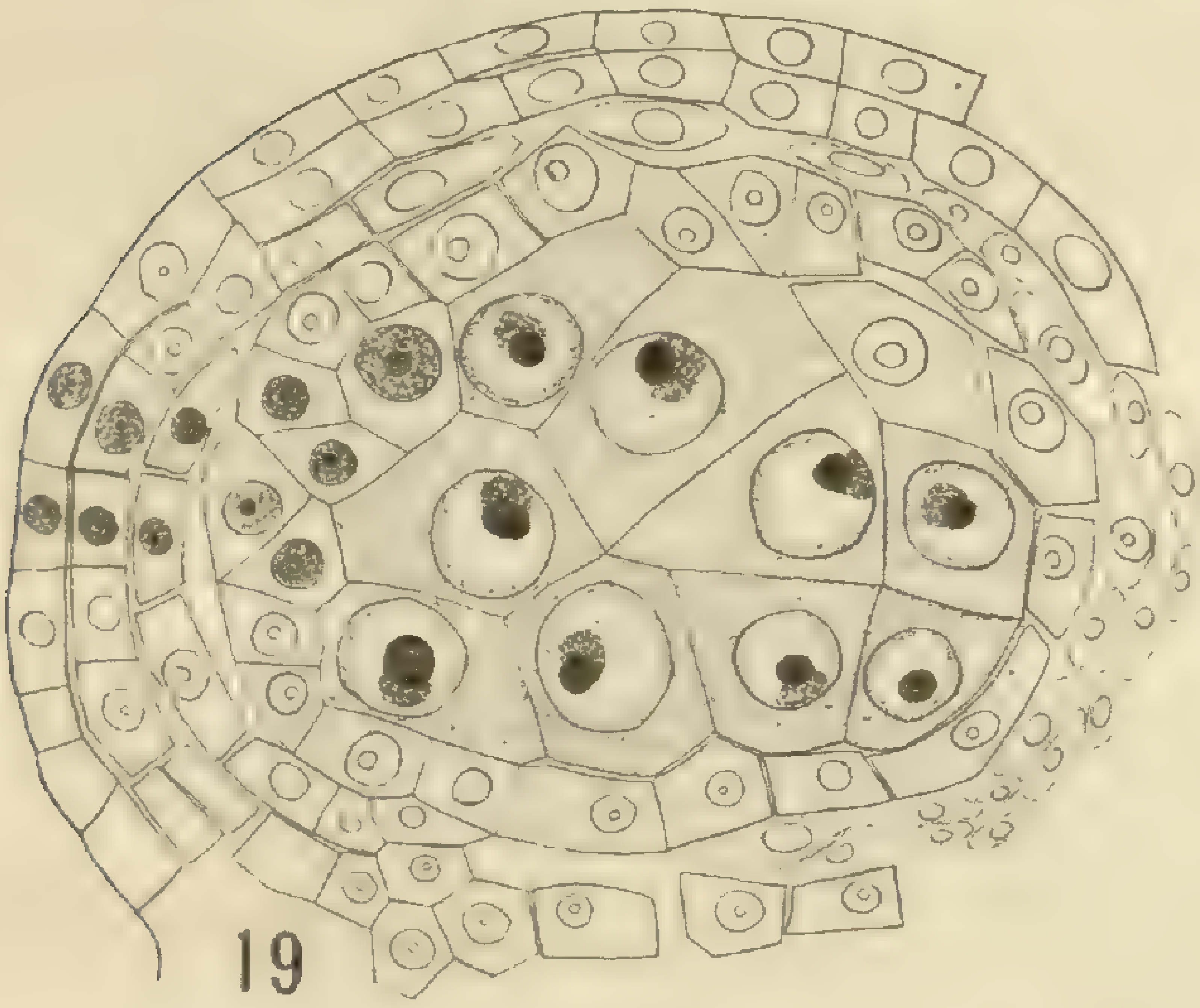


Fig. 17. A single loculus; tapetal layer differentiated about sporogenous cells. × 1375.

Fig. 18. Same as *fig. 17*, but advanced to a stage which shows several wall layers and the tapetum. × 1375.

cell, while in many composites it is equally certain that the tapetum is derived from the wall layers. Warming's account, reproduced by several text-books, refers the tapetum of angiosperms to the wall layers. So far as concerns the spermatophytes, the only evidence offered as to the origin of the tapetum has been the relation of its cells to those on each side of it. If, as appears to be true in this case, the tapetum may be derived either from the sporogenous cells or the wall cells, or perhaps partly from each, it would become clear that it is a physiological rather than a morphological layer. This accords with the conditions found in Ranunculus (**17**) and the suggestions made in that connection.

When the microspore mother cells have become free by the breaking down of their cell walls, the tapetum sometimes divides, forming groups of cells projecting into the mother cell region (*figs. 19, 20, 21, 22*). A large number of cases were observed in which cells of the tapetum were projecting deep into the cavity of the loculus, a very peculiar case being shown in *fig. 23*. These projecting cells evidently served to nourish the mother cells, as the latter were frequently found in close contact with them, as shown in the figure last cited.



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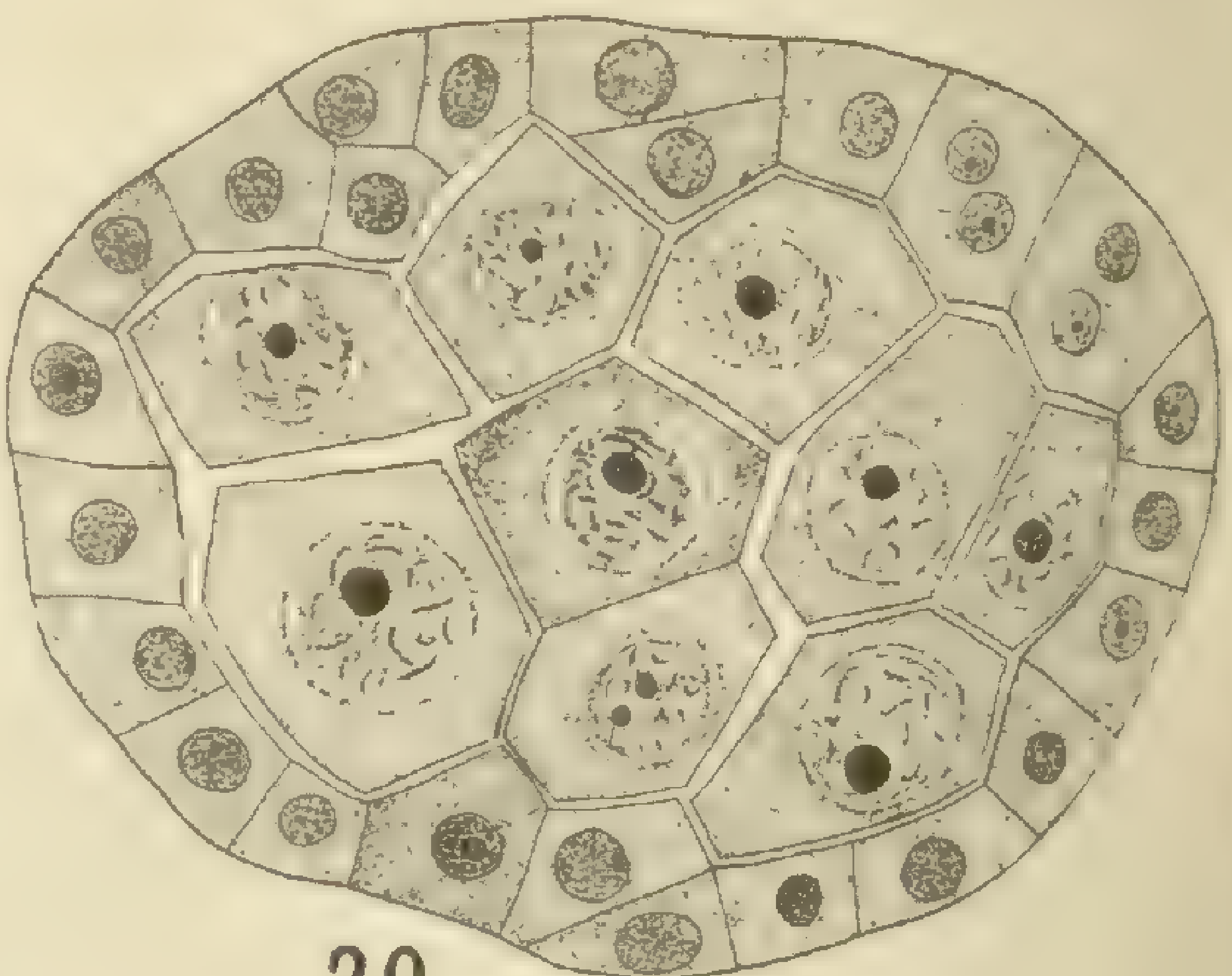

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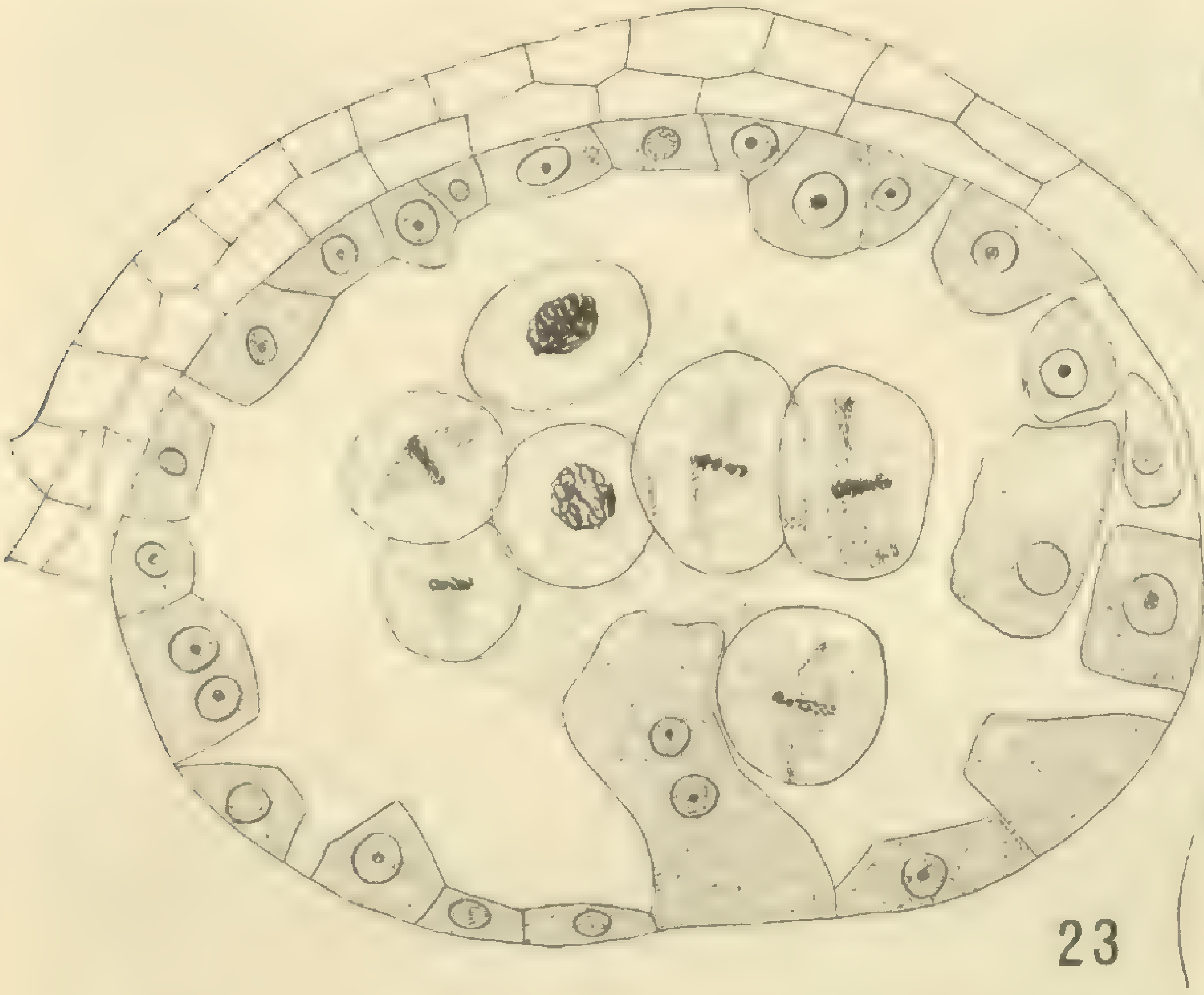
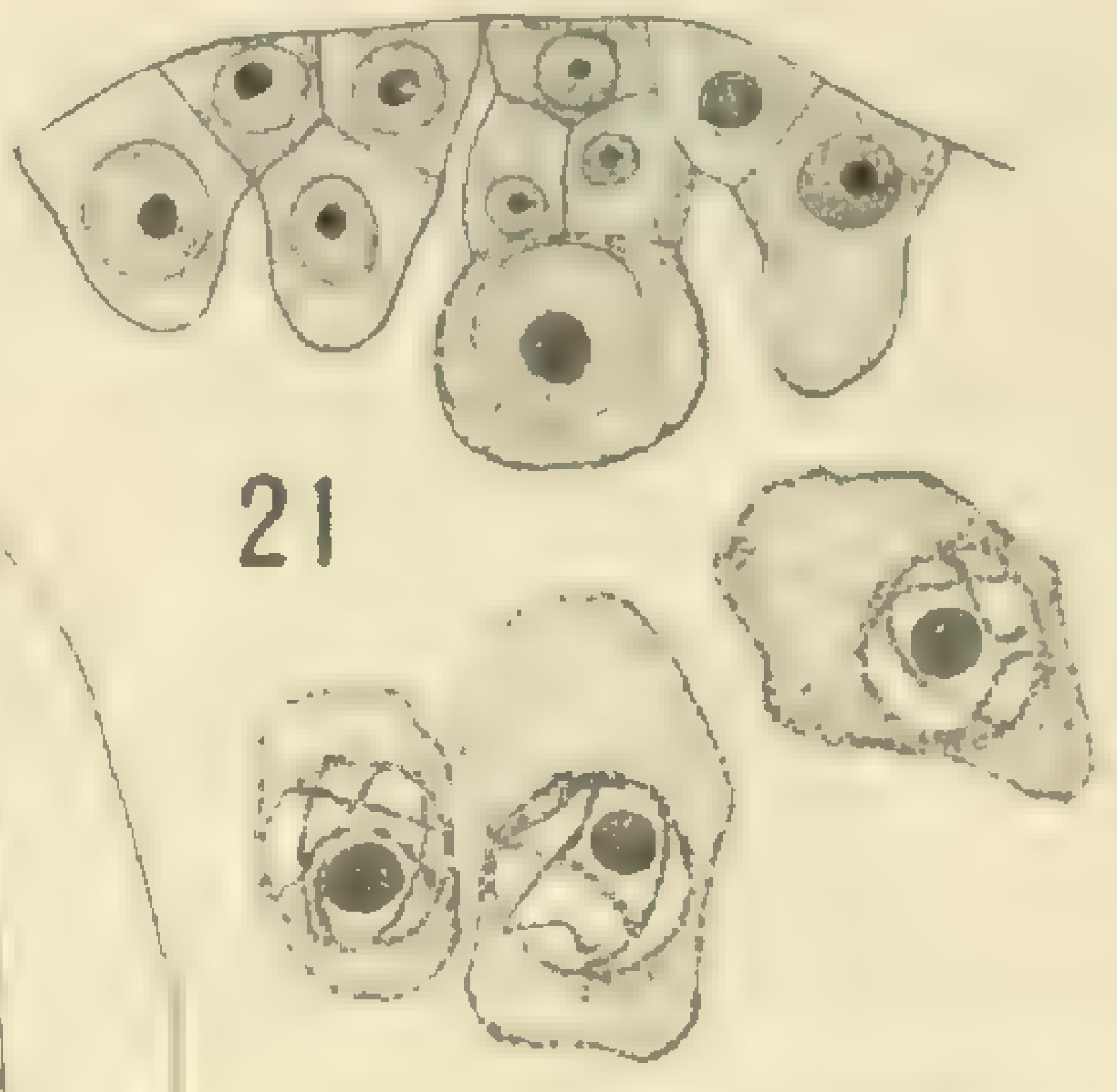
FIG. 19. Loculus with mother cells, the nuclei of which are in synapsis; tapetal cells dividing; wall cells breaking down. × 1375.

FIG. 20. Same as *fig. 19*, with no wall cells. Nuclei in early stages of division. × 1375.

The number of microspore mother cells formed is as large as would be expected in a loculus of this size. A striking fact, however, is that comparatively few of them develop spores, since many disorganize, and together with the tapetum nourish the remaining mother cells (*figs. 24, 25*). These broken down mother cells frequently form incomplete chains extending into and almost across the loculus, though such masses are usually found near the tapetum. They react to stains as the tapetum, and doubtless assume the function of the latter as nutritive tissue. Similar conditions are well known in Salvinia and Azolla, where disintegrating mother cells gather about the remaining ones and nourish them. In *Lilæa subulata* (**18**), also, there are certain cells between the sporogenous tissue and the tapetum which seem to represent those just described.





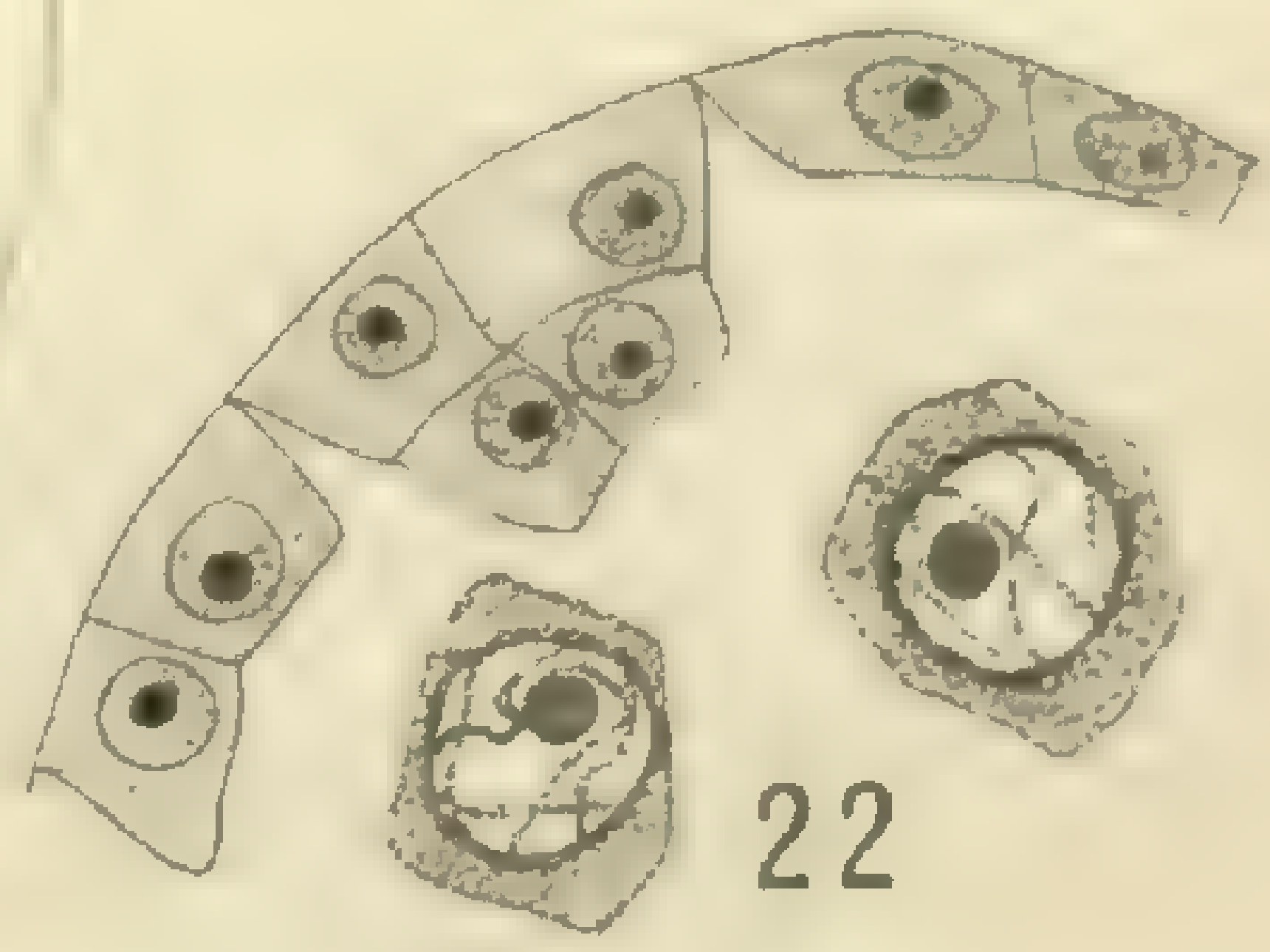
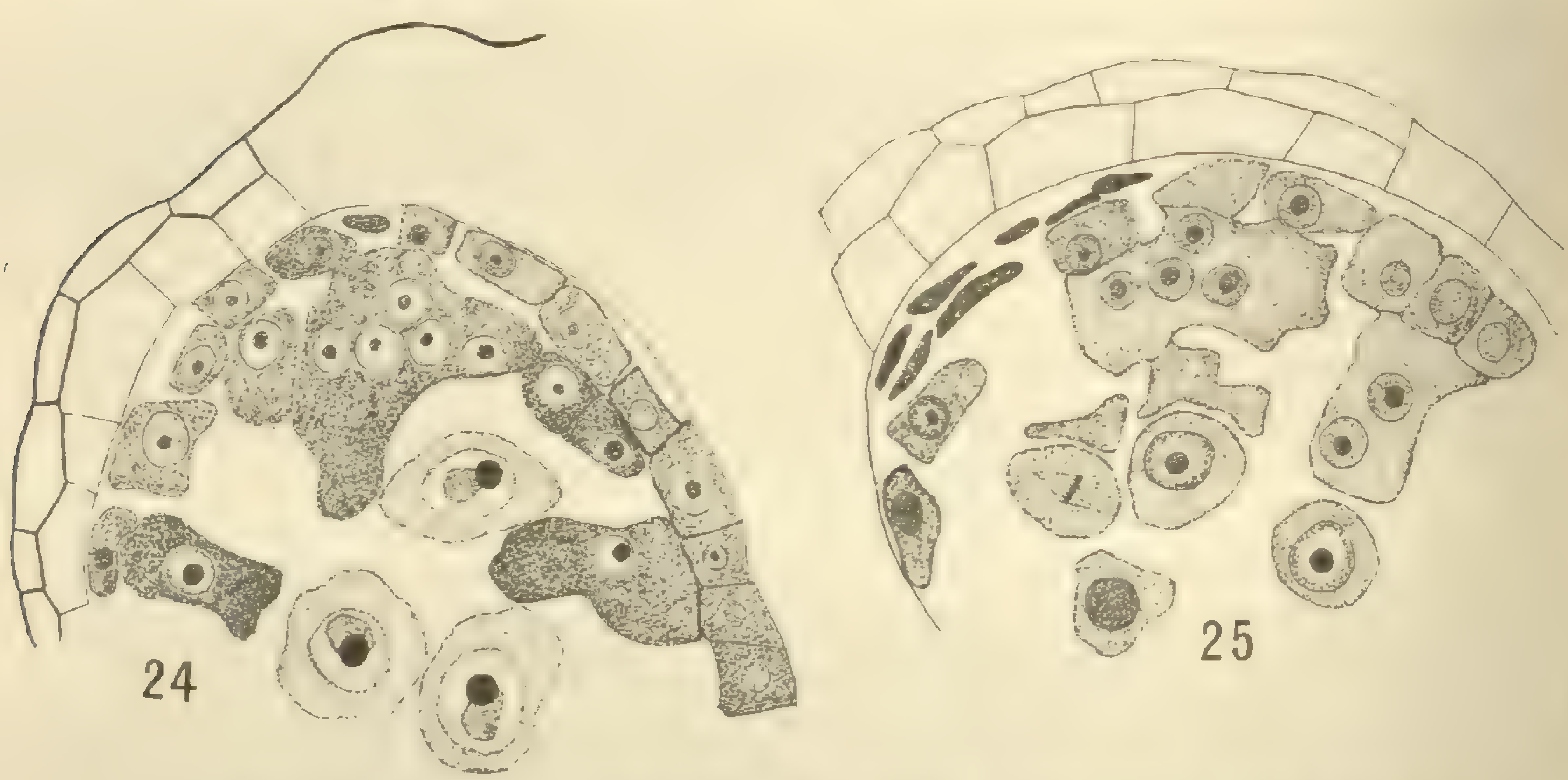


FIG. 21. Spore mother cells with distinct chromatin bands in nuclei, and irregular masses of cytoplasm about them; some tapetal cells divided. × 1375.

FIG. 22. Part of loculus; mother cells with divided tapetal cells. × 1375.

FIG. 23. Loculus with spore mother cells dividing; one tapetal cell has elongated very greatly, its nucleus having divided. × 1375.

Each functioning mother cell gives rise to four microspores by first dividing into two divisions, each of these again dividing by spindles in the same plane as the first, but with their longitudinal axes transverse to it (*figs. 23, 26, 27, 28*). Soon after these divisions have occurred the spores assume a spherical form and increase greatly in size.

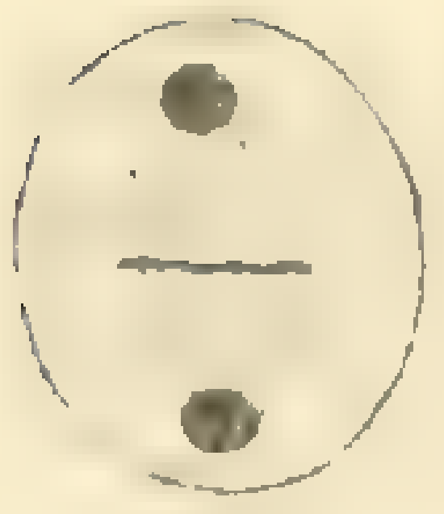


FIGS. 24, 25. Some of the mother cells broken down and lying more or less attached to the tapetum. × 1375.

GERMINATION OF THE MICROSPORE.

The walls of the spore thicken, and, after a short period of rest, the nucleus shows signs of the approaching germination (*fig. 30*). In *fig. 31* is shown a case of division of the microspore nucleus. At the ends of the spindle are distinct granules of unequal size, while near the spindle in the cytoplasm are other granules, apparently of the same nature, so far as appearance and staining reaction can testify. The spores at this time are usually well filled with refractive food masses.

Usually, though not always, the first division results in the placing of one daughter nucleus near the wall of the microspore (*fig. 32*). The nucleus so placed is the nucleus of the generative cell. This cell is small, slightly lenticular in outline, and stains a little more deeply than the large cells of the germinating microspore (*figs. 33–39*). It remains more or less closely applied to the wall of the spore for a short time, then after moving a little distance from the wall divides (*fig. 30*). The spindle of this division is smaller than that of the preceding one, the resulting nuclei being also smaller (*figs. 38, 39*). By the time these divisions have been completed the outer spore wall is quite heavy, and is covered irregularly with spiny outgrowths.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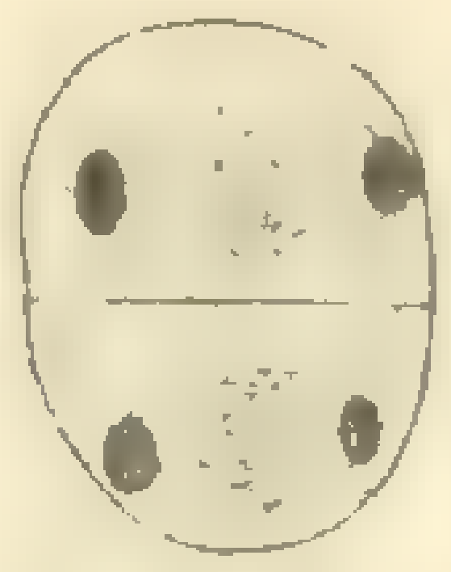
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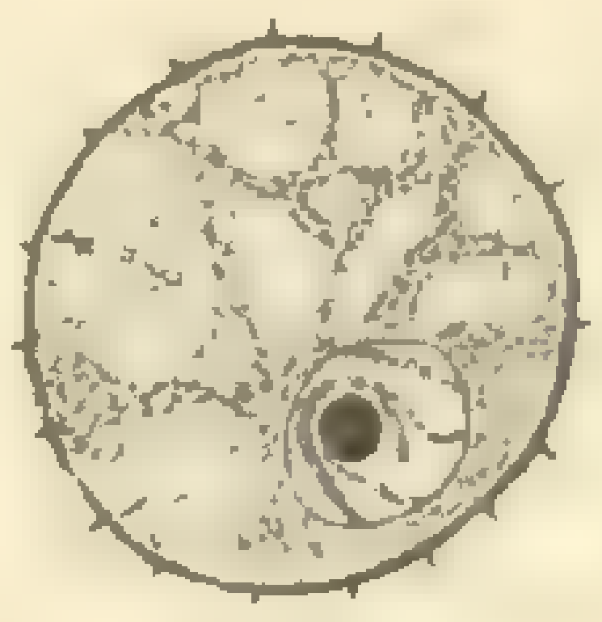
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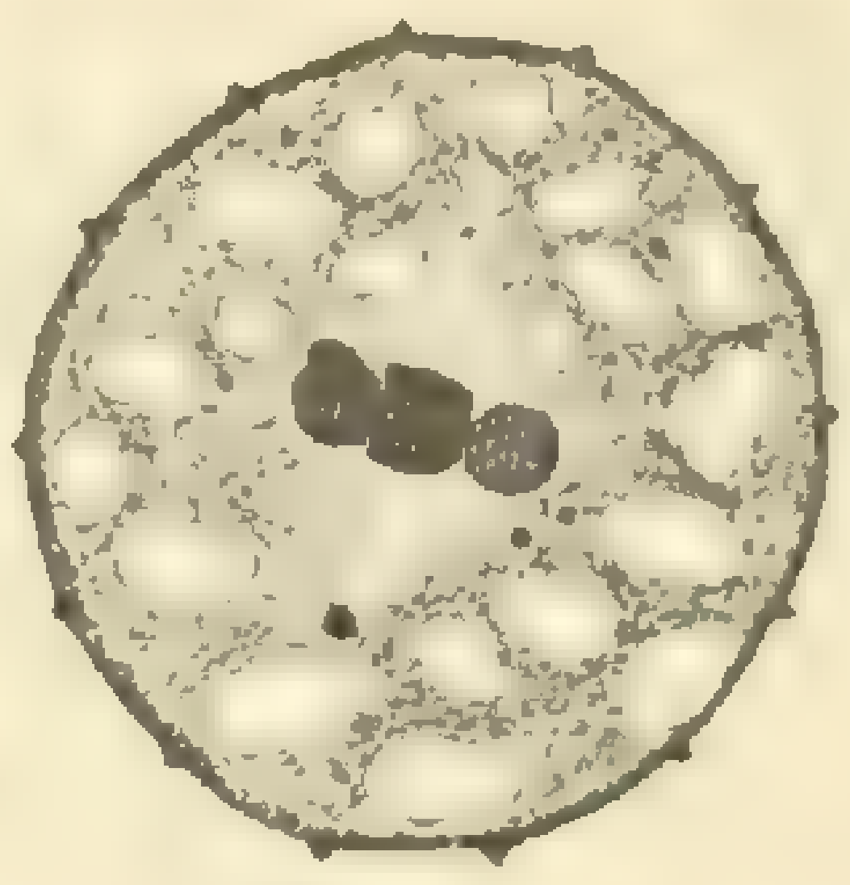
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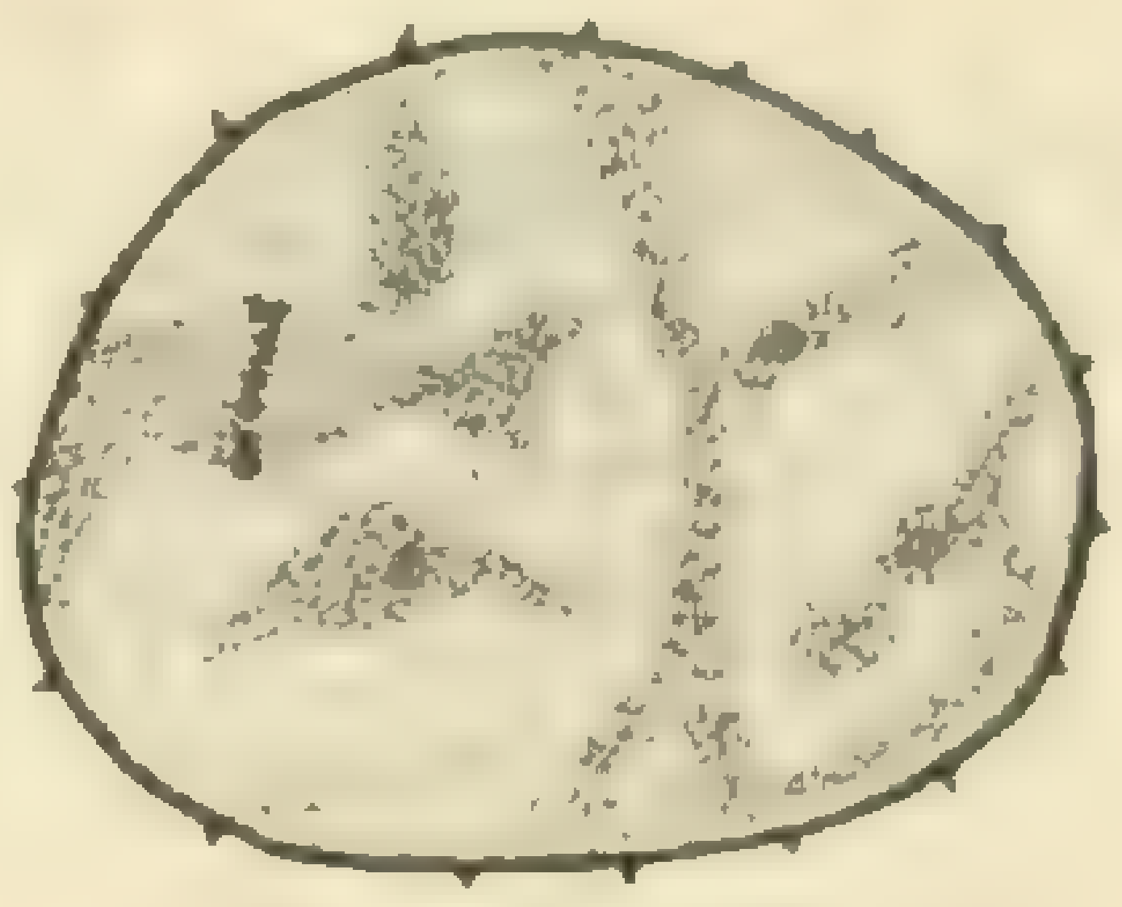
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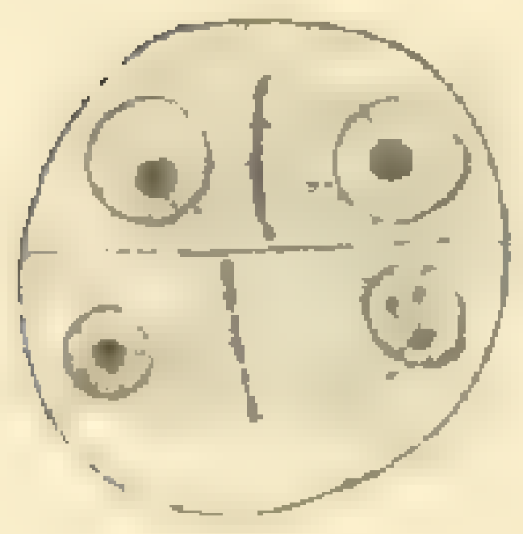
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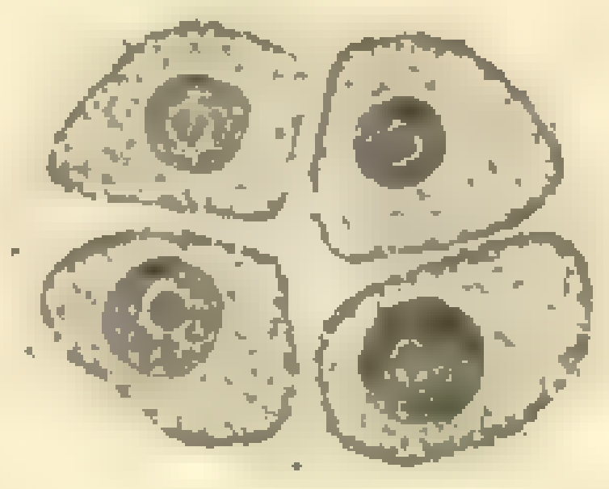
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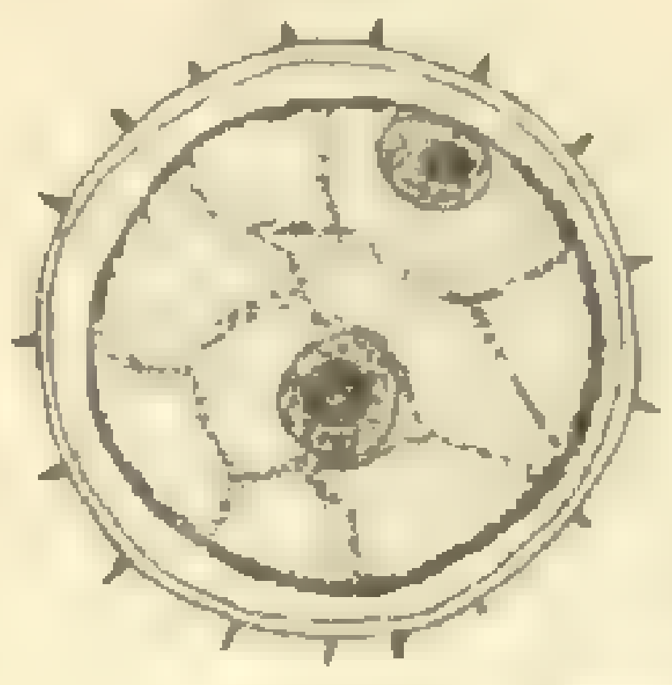
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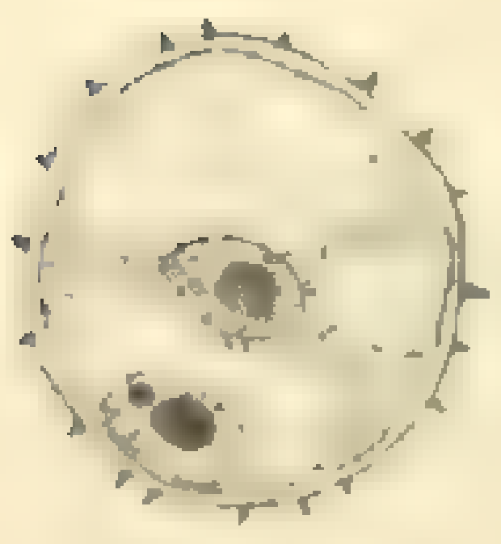
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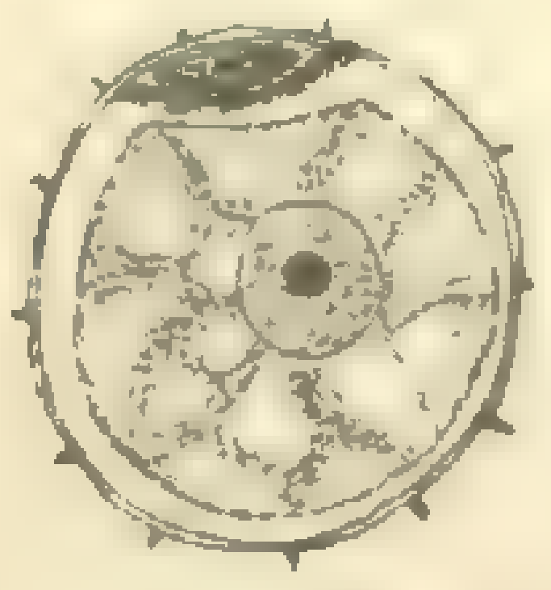
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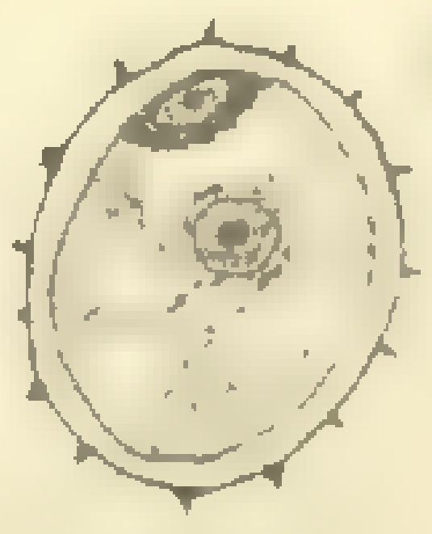
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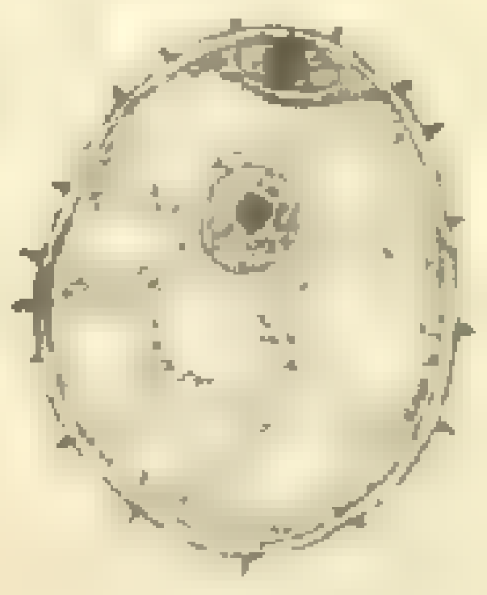
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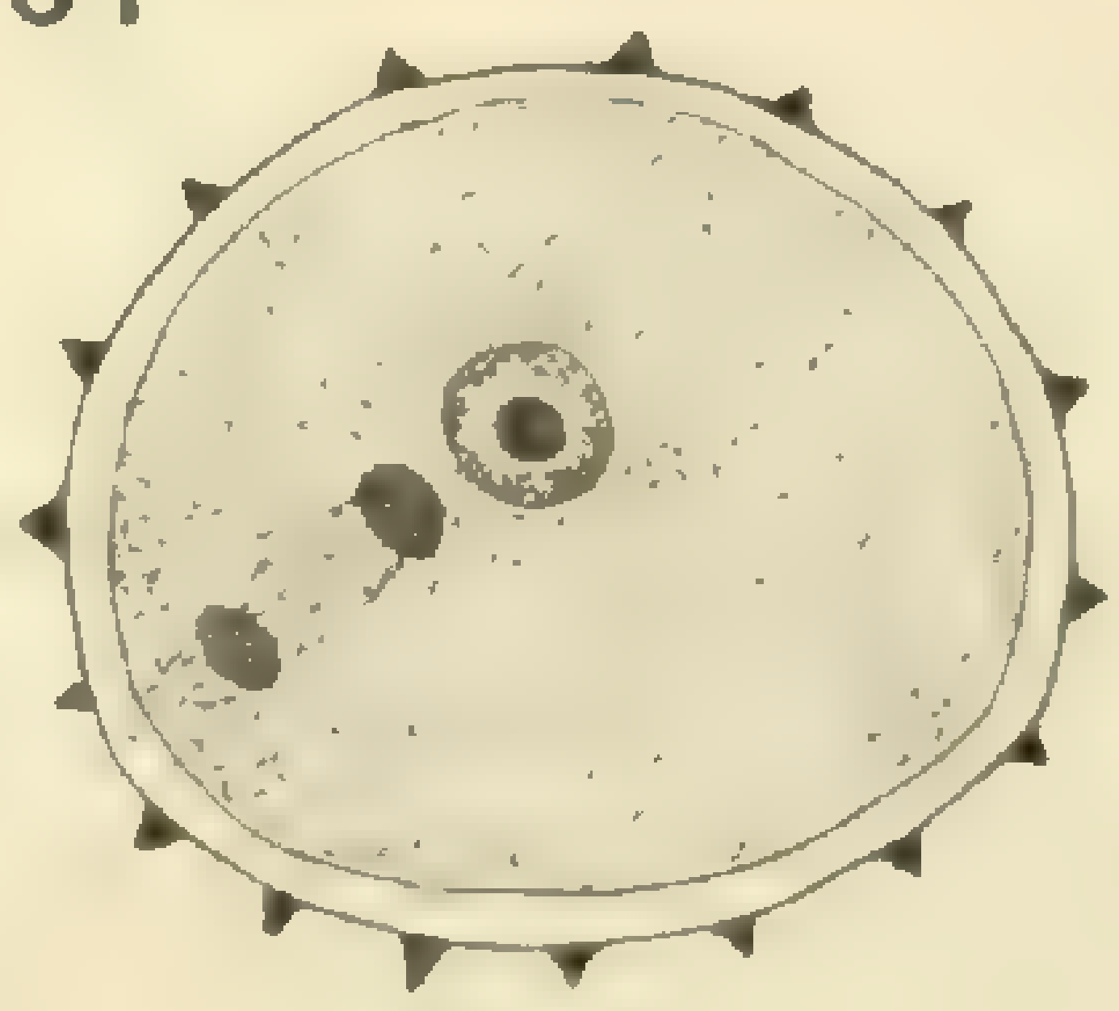
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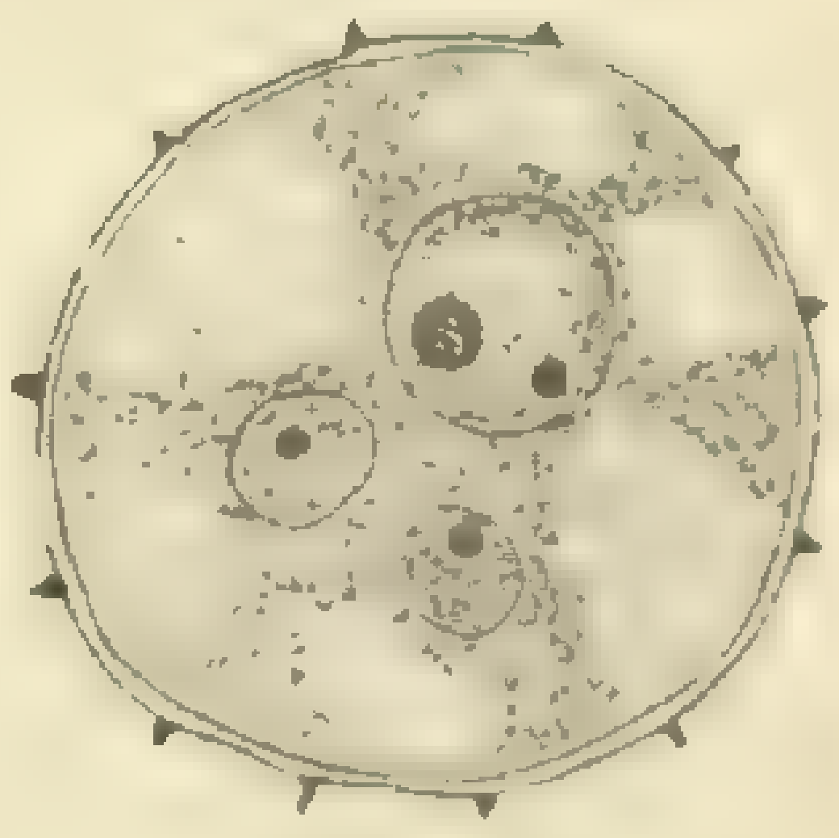
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FIGS. 26–29. Formation of tetrads. × 1375.

FIG. 30. Microspore in which the nucleus indicates approaching germination × 1375.

FIG. 31. First division of the nucleus of the microspore; granules at ends of spindle and in adjacent cytoplasm. × 2400.

FIG. 32. Same as *fig. 31*. Position of spindle which places one daughter nucleus near wall of spore. × 2400.

FIGS. 33–37. Microspores after first division of nucleus; one cell placed near the wall. × 1375.

FIG. 38. Microspore with generative cell dividing. × 2400.

FIG. 39. Same as *fig. 38*, showing male cells. × 2400.

No indications of thinner regions of the spore wall, especially developed to facilitate the escape of the pollen tube, could be found.

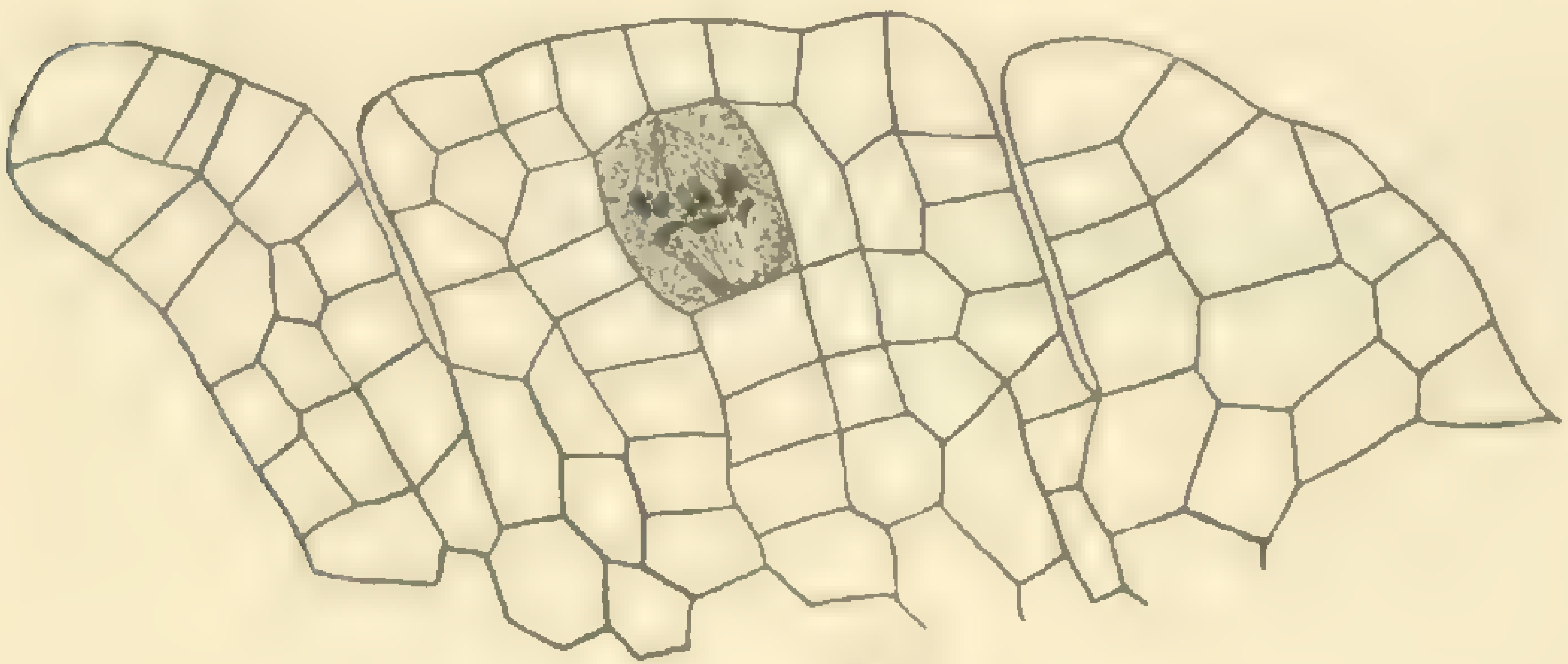
Before this time the tissues separating the two loculi on each side have broken down, forming the two pollen sacs. These break open and the spores float out upon the water. The microspores of the two anthers are not in the same stage of development at the same time. When the mother cells of the older anther are beginning to divide, the corresponding cells of the younger anther are just becoming free in the mucilaginous material of the broken down cell walls and tapetum. Consequently the microspores are not discharged from the two anthers of a flower at the same time.

CARPELS.

When the stamens are in the stages of development shown in *figs. 14* and *15*, the beginning of the ovule usually may be distinguished. In *fig. 8* the nucellus appears as the elevation in the center, while the outgrowth shown in section on either side is the beginning of the carpel. The walls of the carpel grow very rapidly, soon extending beyond the tip of the nucellus, at which point they approach each other. Instead of the carpel walls coming together immediately above the nucellus to form a solid style, there is a canal which in the adult carpel extends from one-fourth to one-half the length of the style. The outer end of the carpel is also deeply funnel-shaped, thereby greatly reducing the amount of tissue through which the pollen tube must pass. As the young carpel develops, it presses against the upper wall of the flower pouch. This causes it gradually to change its direction until its longitudinal axis lies almost in the plane of the axis of the stamens (*fig. 9*). When the tip of the carpel escapes from the spathe the funnel-shaped stigma turns upward (*figs. 1, 2*). Whether this is merely an attempt to come to the surface of the water to catch pollen grains, or to extend above the surface to protect the mucilaginous secretion, I could not determine. In either case it seems clear that the deep funnel-shaped tip is well constructed to hold pollen grains which have once become lodged therein.

OVULES.

The axial ovule begins to grow with its apex pointed almost directly toward the surface of the plant, its longitudinal axis being at an angle of about 60° from that of the stamens, which it will be remembered lie in a plane almost parallel to the surface of the frond. The nucellus appears first, as a few-celled papilla, which very early has at its sides the projections from which the integuments develop (*figs. 40, 41*). On one side the integuments grow much more rapidly than on the other, so that when the ovule is fully formed the embryo sac lies perpendicular to the stalk of the ovule (*figs. 9, 10, 42*), and in a plane parallel to the surface of the frond, with its micropylar end toward the base of the frond. It must be borne in mind that while the ovule when young was orthotropous, and gradually became half anatropous, the carpel has also changed from an upright position to one which is prostrate. Thus the position of the ovule has constantly changed in two directions during growth, making it extremely difficult to obtain sections showing the successive stages in the growth of the carpel, ovule, and embryo sac. This difficulty will be more fully appreciated when it is remembered that the flowers are so small that it is impossible to orient them, or to determine their respective ages except under high magnification. As a result of these conditions most of the hundreds of series of sections made were of no great value.



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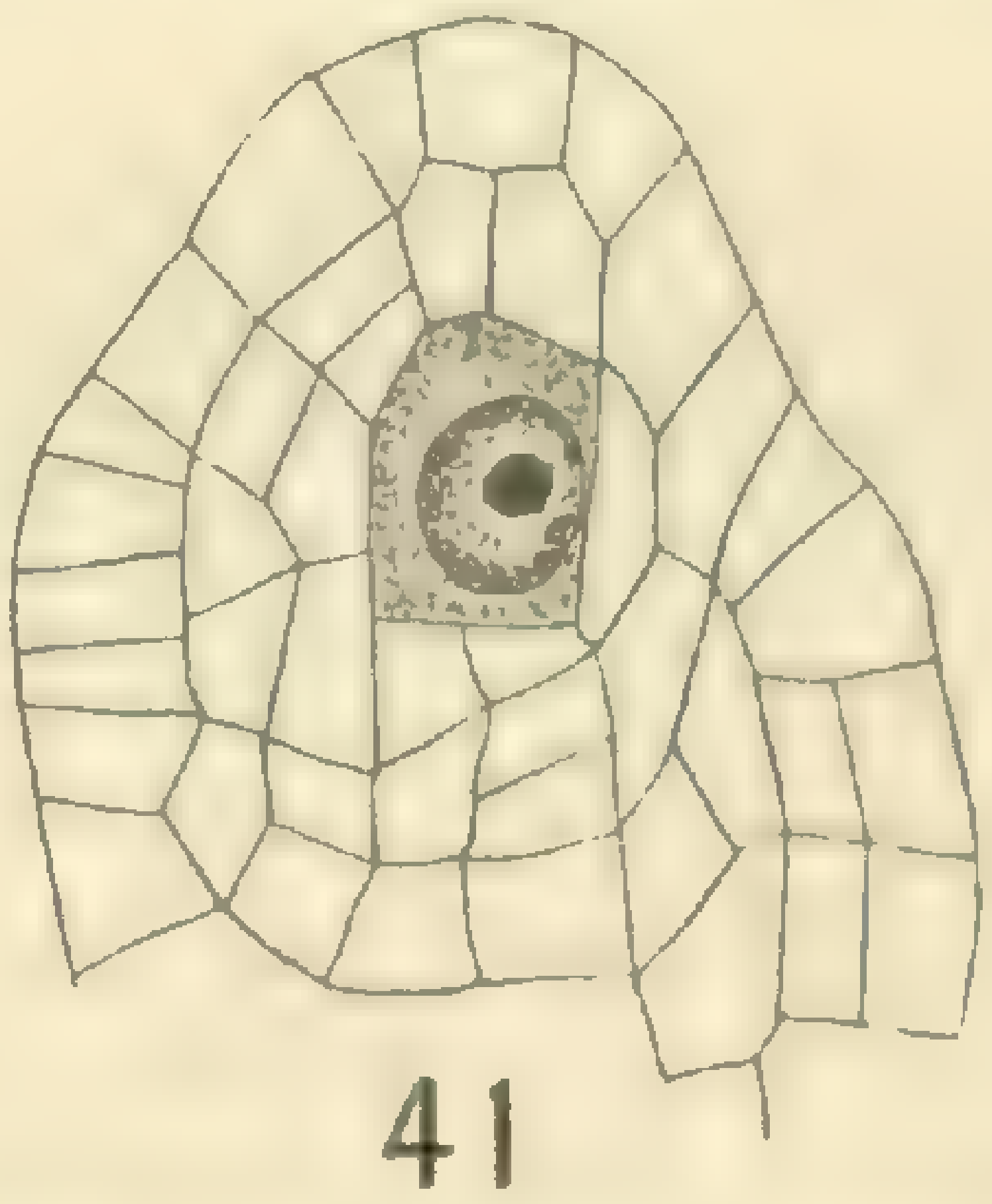

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FIG. 40. Nucellus with dividing archesporial cell ; at each side the beginning of the carpel ; at rim of nucellus the beginning of first integument. × 1375.

FIG. 41. Nucellus, with megaspore, tapetal cells, and beginning of integuments. × 1375.

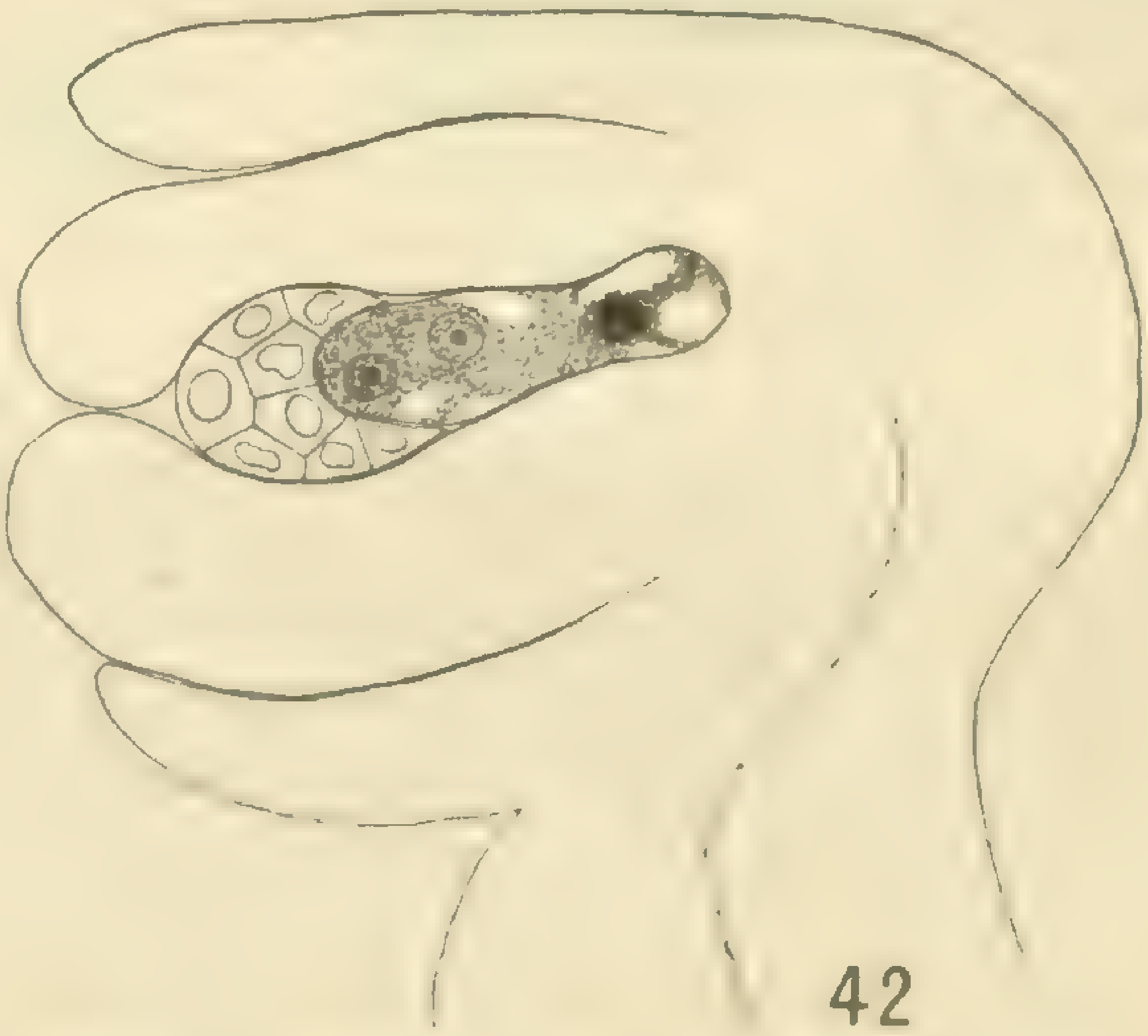

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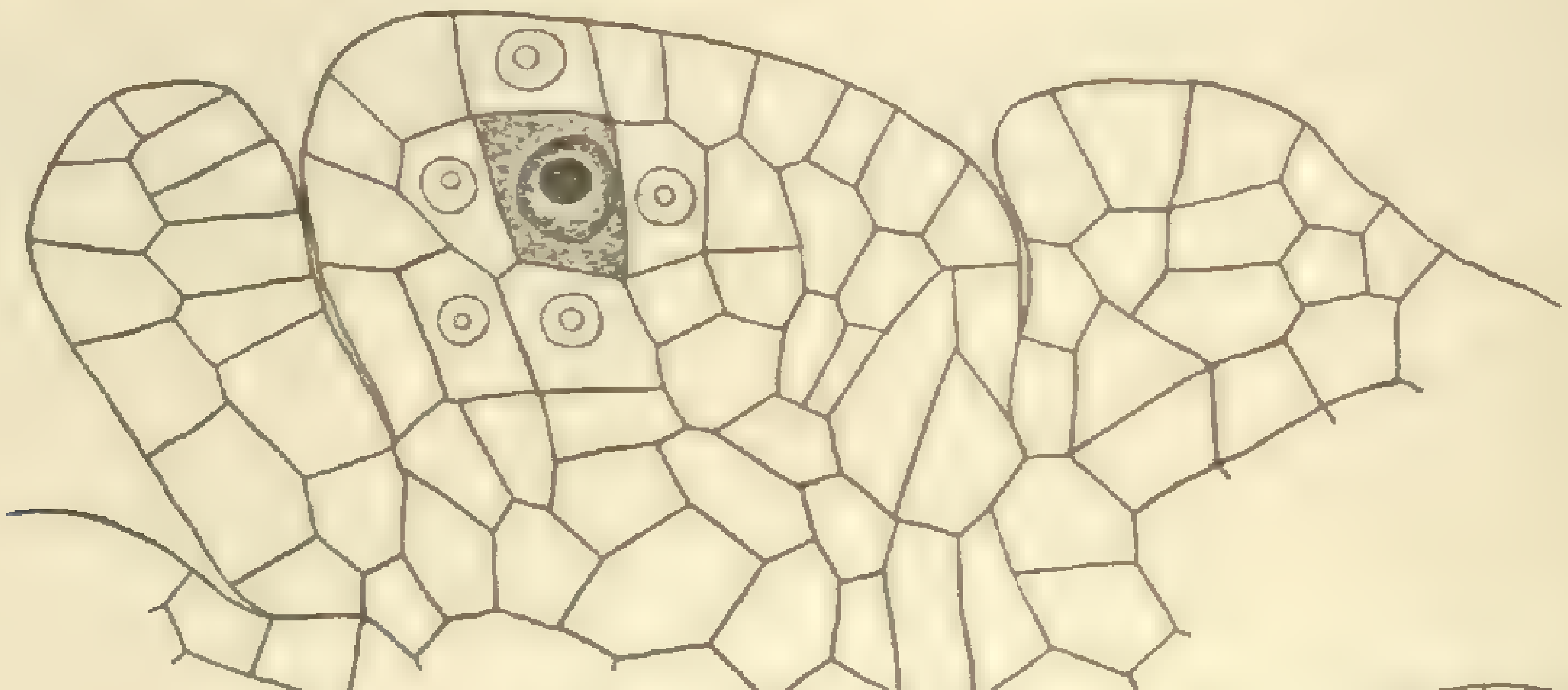
FIG. 42. Ovule with embryo sac in which antipodal nucleus is disintegrating; the nucellus caps the embryo sac. × 890.

FORMATION OF THE MEGASPORE.

Quite early in the development of the ovule an archesporial cell (*fig. 43*) may be distinguished by its greater size and greater avidity for stains. Its cytoplasm stains much more darkly than that of adjacent cells, while its nucleus takes a less intense stain. This cell enlarges rapidly and soon divides (*fig. 40*), giving rise to the primary tapetal cell and the primary sporogenous cell (*figs. 44, 45*), this division usually occurring about when the carpel begins its rapid growth around the ovule (*fig. 45*). The primary tapetal cell may divide by a wall perpendicular to the one which separated it from the primary sporogenous cell (*fig. 41*). I found no cases indicating that it divides by periclinal walls to form a tapetal row. Later stages do not show more than two layers of cells above the tip of the embryo sac, and since nothing was found which could be interpreted as remains of tapetal cells the conclusion that no later development occurs seems justified. The loss of differentiation in reaction to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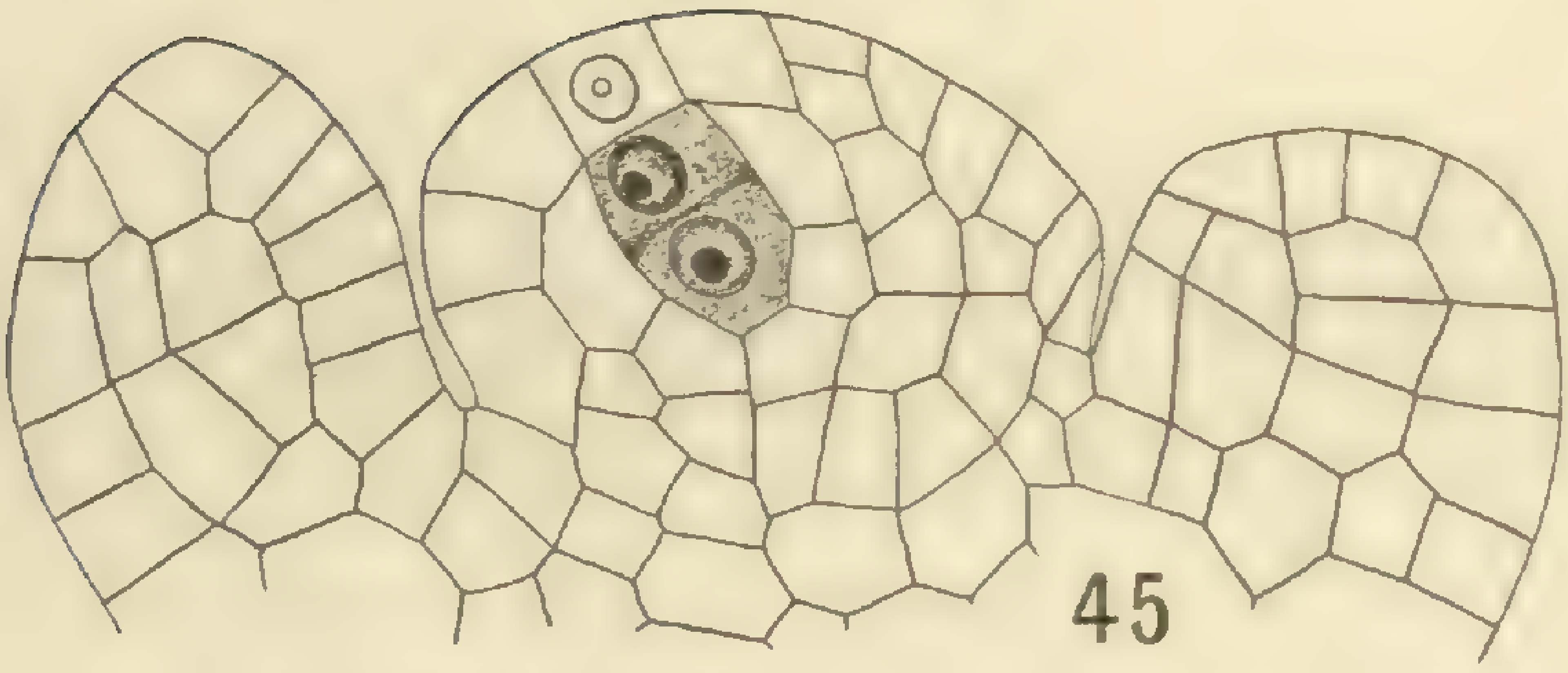
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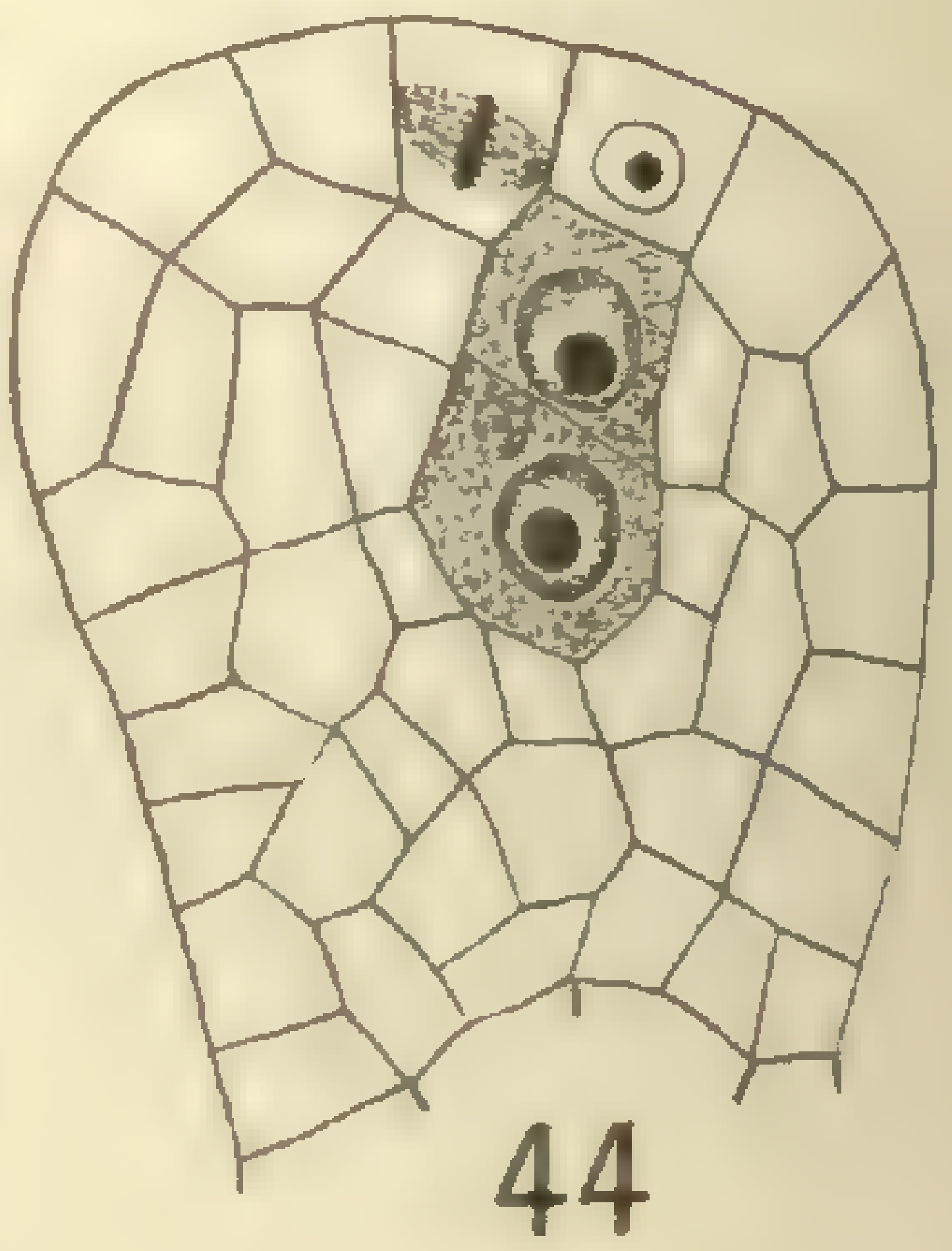
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FIG. 43. Nucellus with archesporial cell. × 1375.

FIGS. 44, 45. Same as *fig. 43*, but archesporial cell has divided, forming primary tapetal and primary sporogenous cells. × 1375.

stains soon renders the tapetal cell indistinguishable from the nucellar cells about it.

The primary sporogenous cell seems to develop directly into the megaspore, and as such undergoes a long period of rest. Meanwhile the integuments push beyond and enclose the nucellus. After the megaspore is formed the cells of the unusually small nucellus undergo no further divisions.

GERMINATION OF THE MEGASPORE.

The enlarging megaspore encroaches upon the nucellus, which, as will be seen from the figures, presently consists of a few cells which are so arranged as to form a cap to the growing megaspore. The sides of the megaspore are bounded by the integuments, and its lower end by the chalazal region of the ovule. The nucellus is crowded into the micropyle, and frequently has some of its cells absorbed by the megaspore, although

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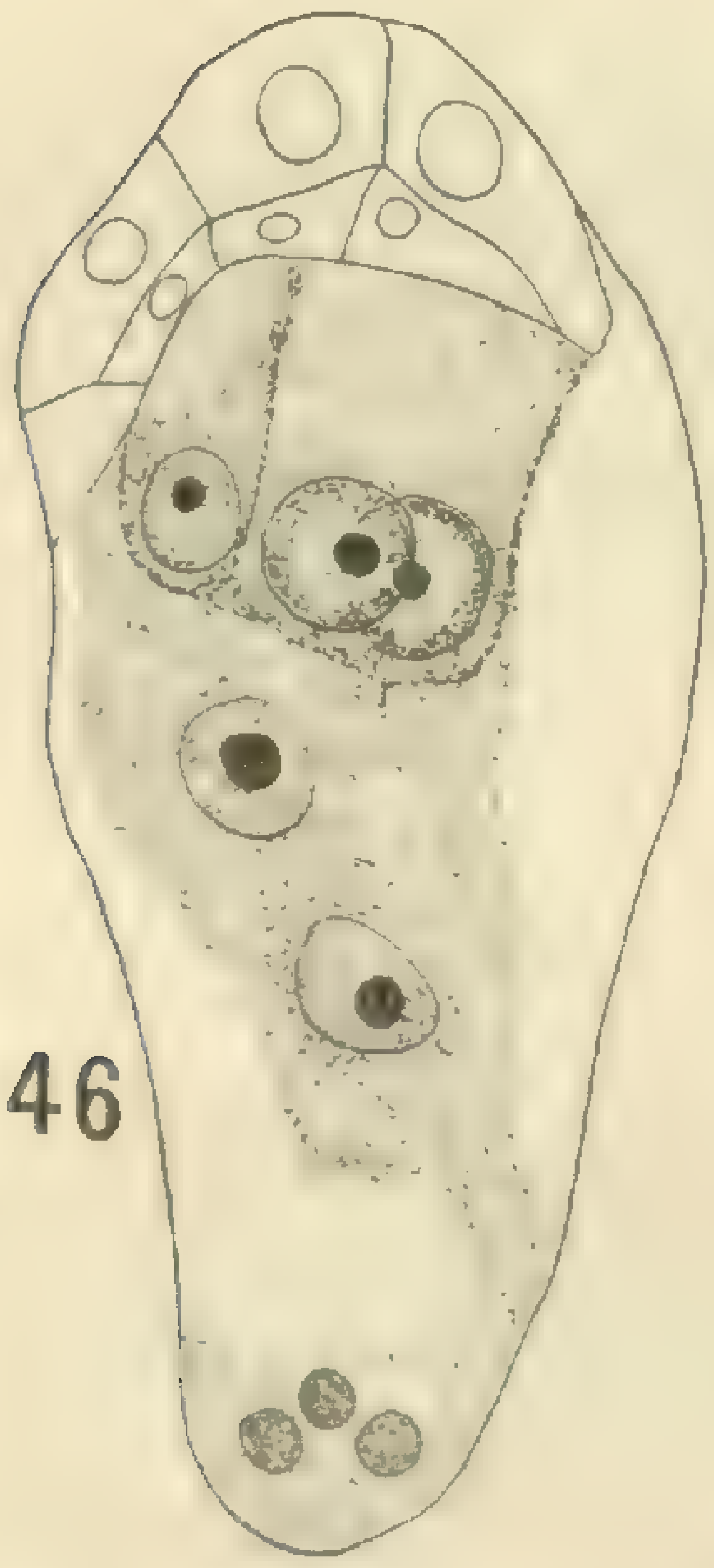

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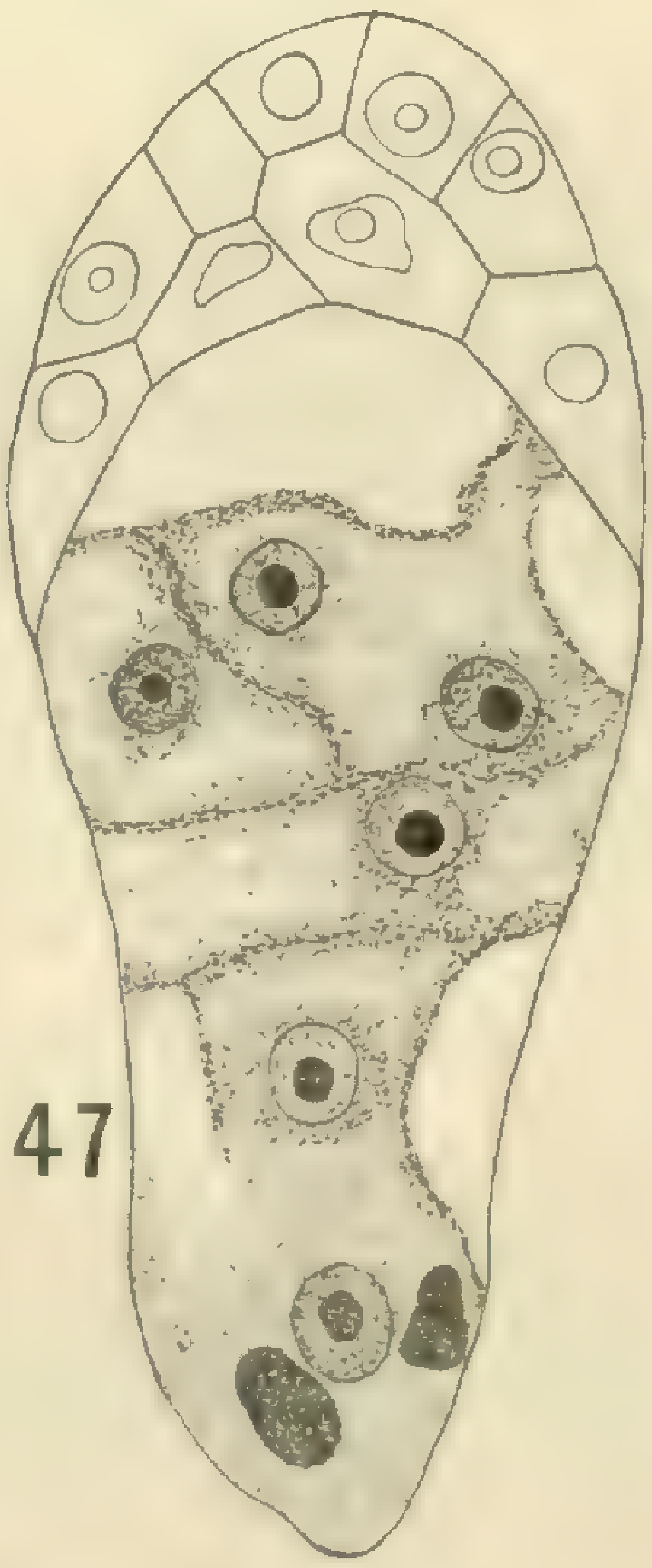

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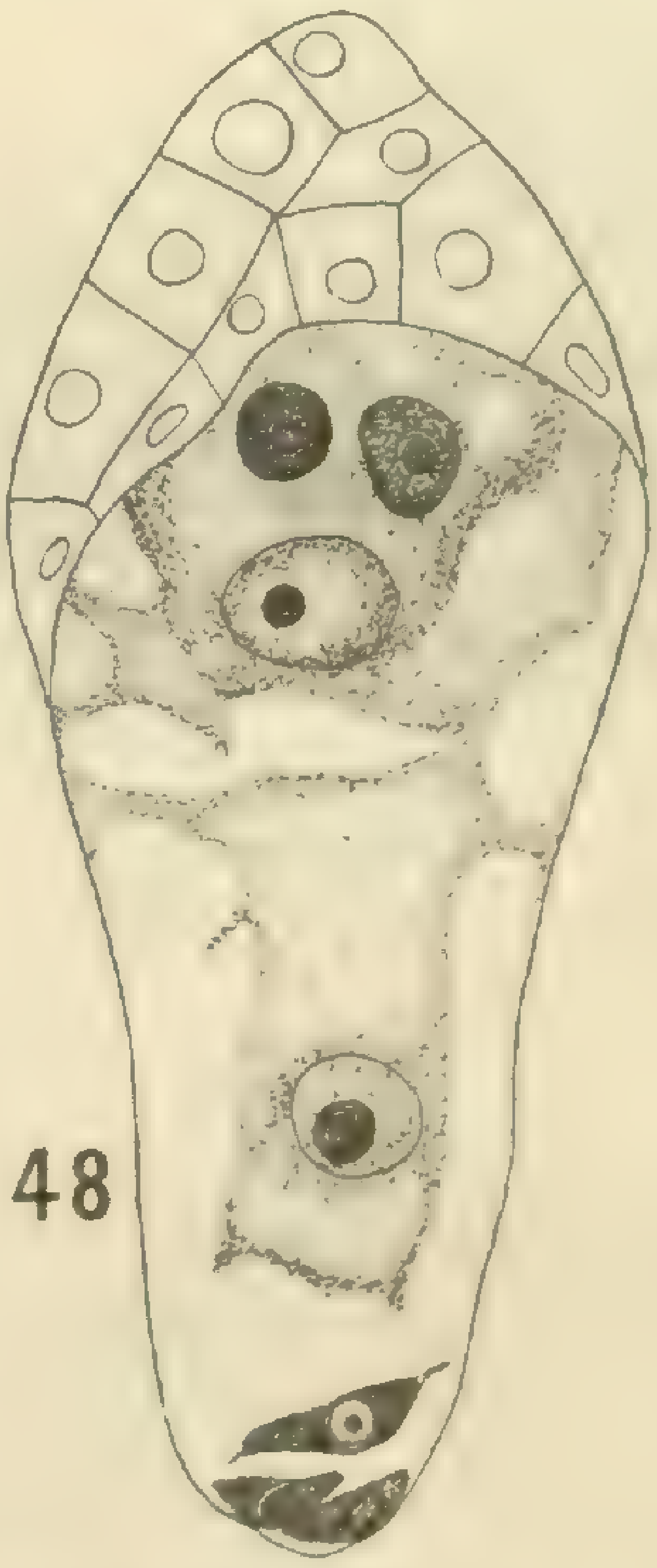
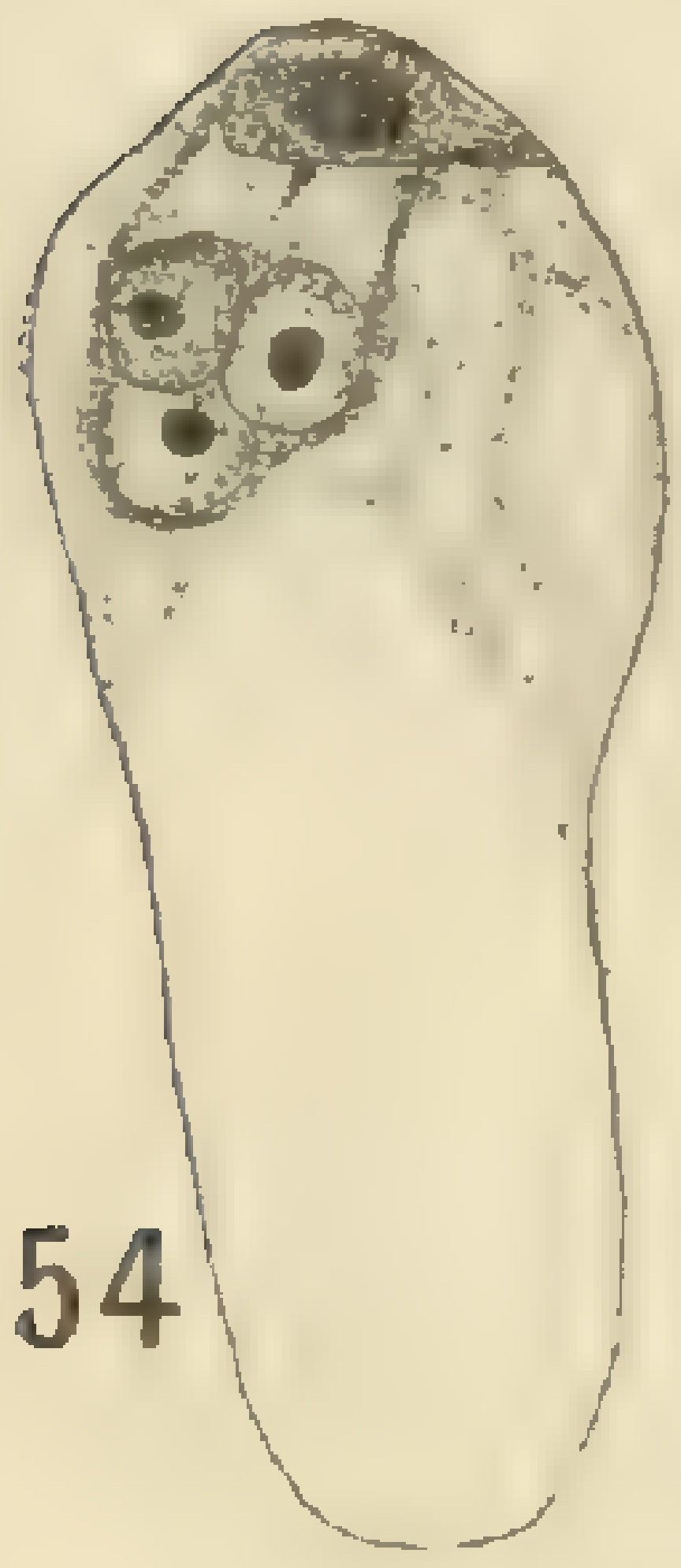


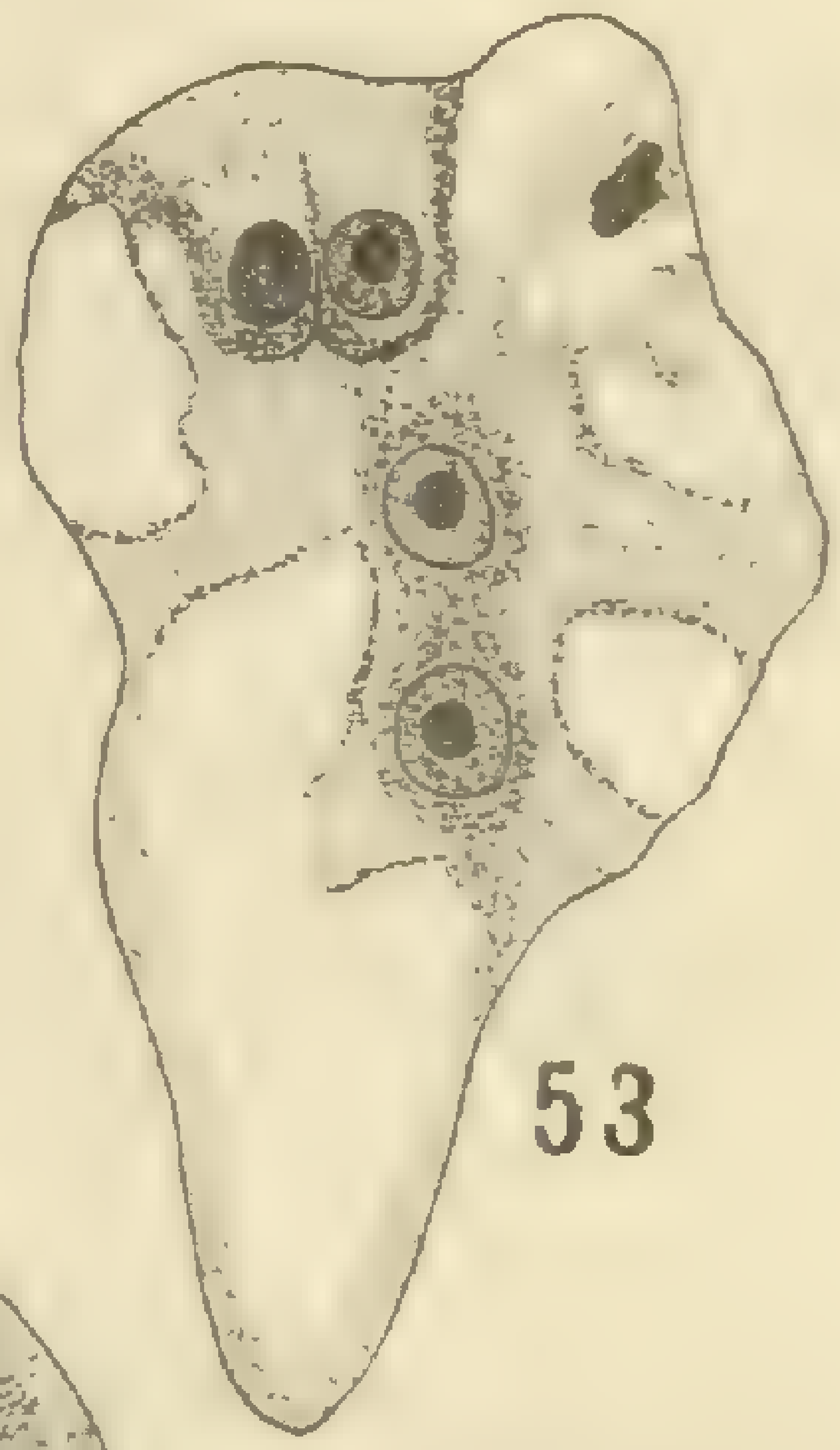
FIG. 46. Eight-celled embryo-sac with nucellus capping micropylar end. × 1375.

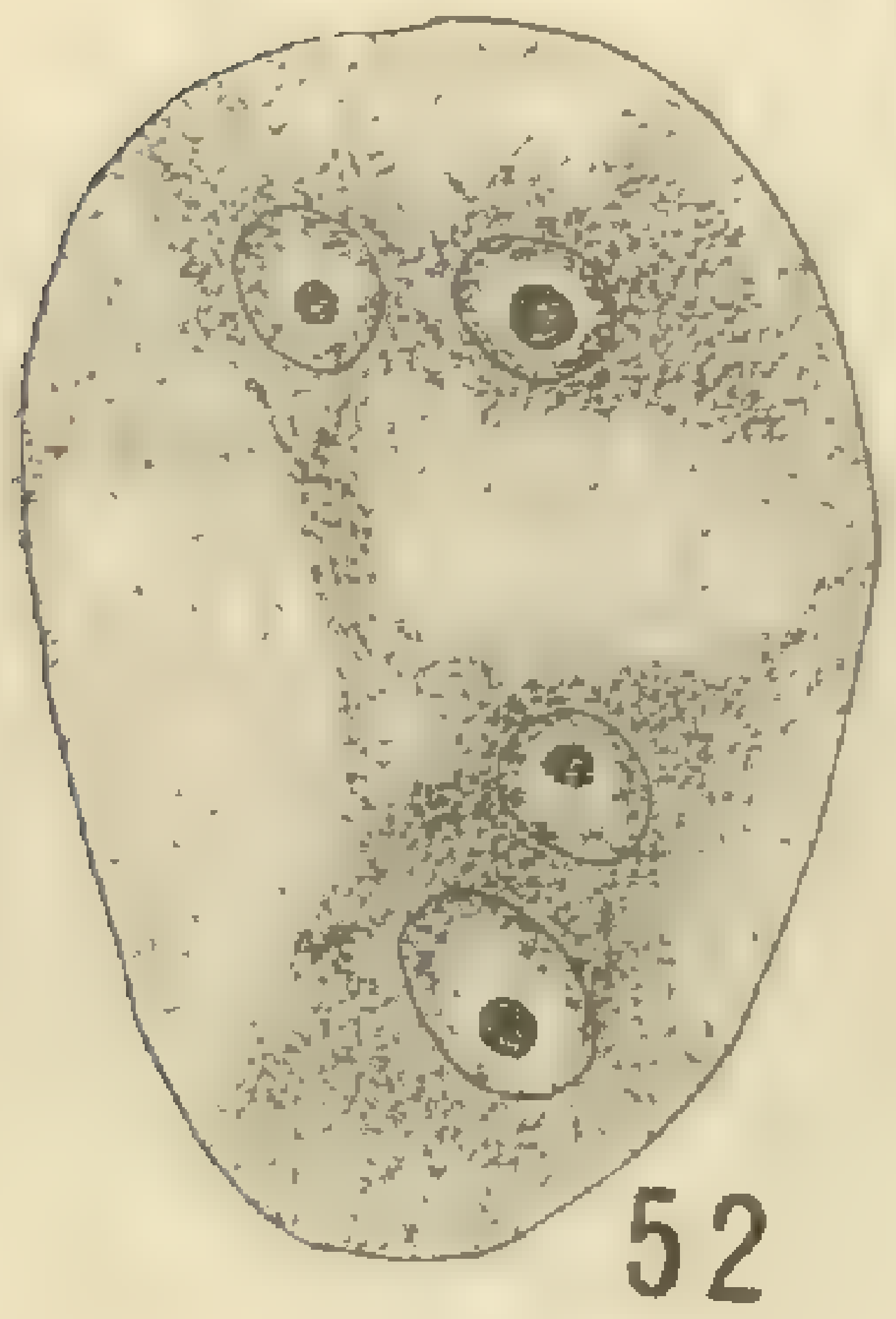
FIG. 47. Probably an eight-celled sac. × 1375.

FIG. 48. Sac with oospore, synergids, primary endosperm nucleus, and antipodals. × 1375.

its outline usually remains rather definite until late stages (*figs.* *46, 47, 48, 49, 50*). This same condition was found in *Pistia Stratiotes;* while in *Allium Canadense* (19) the nucellus is said to disappear quite early.







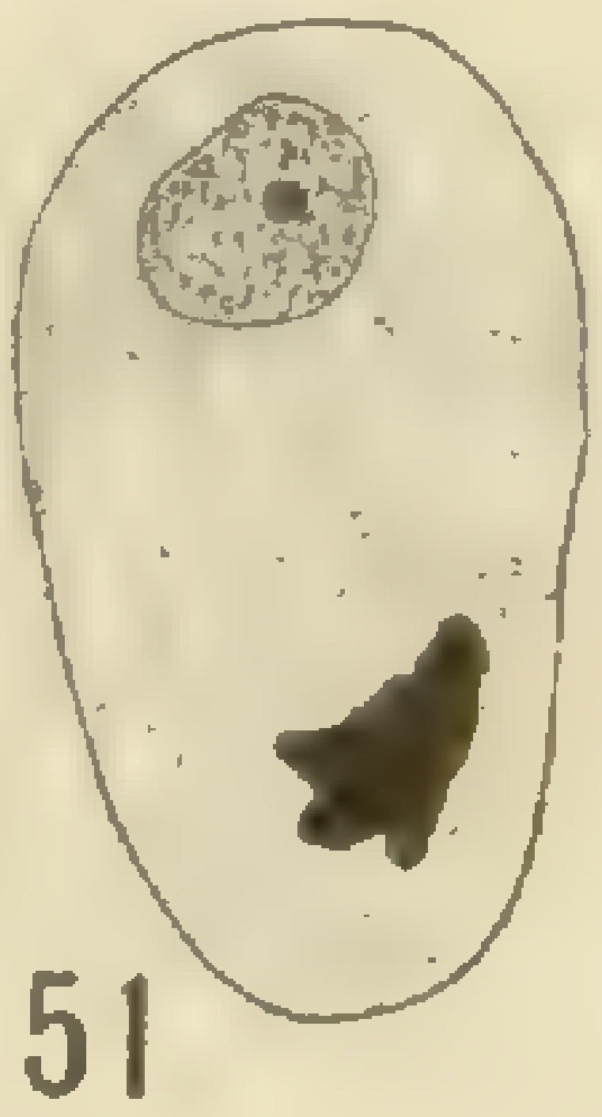


FIG. 51. Two-celled sac in which antipodal nucleus is disintegrating. × 1375.

FIG. 52. Four-celled sac. × 1375.

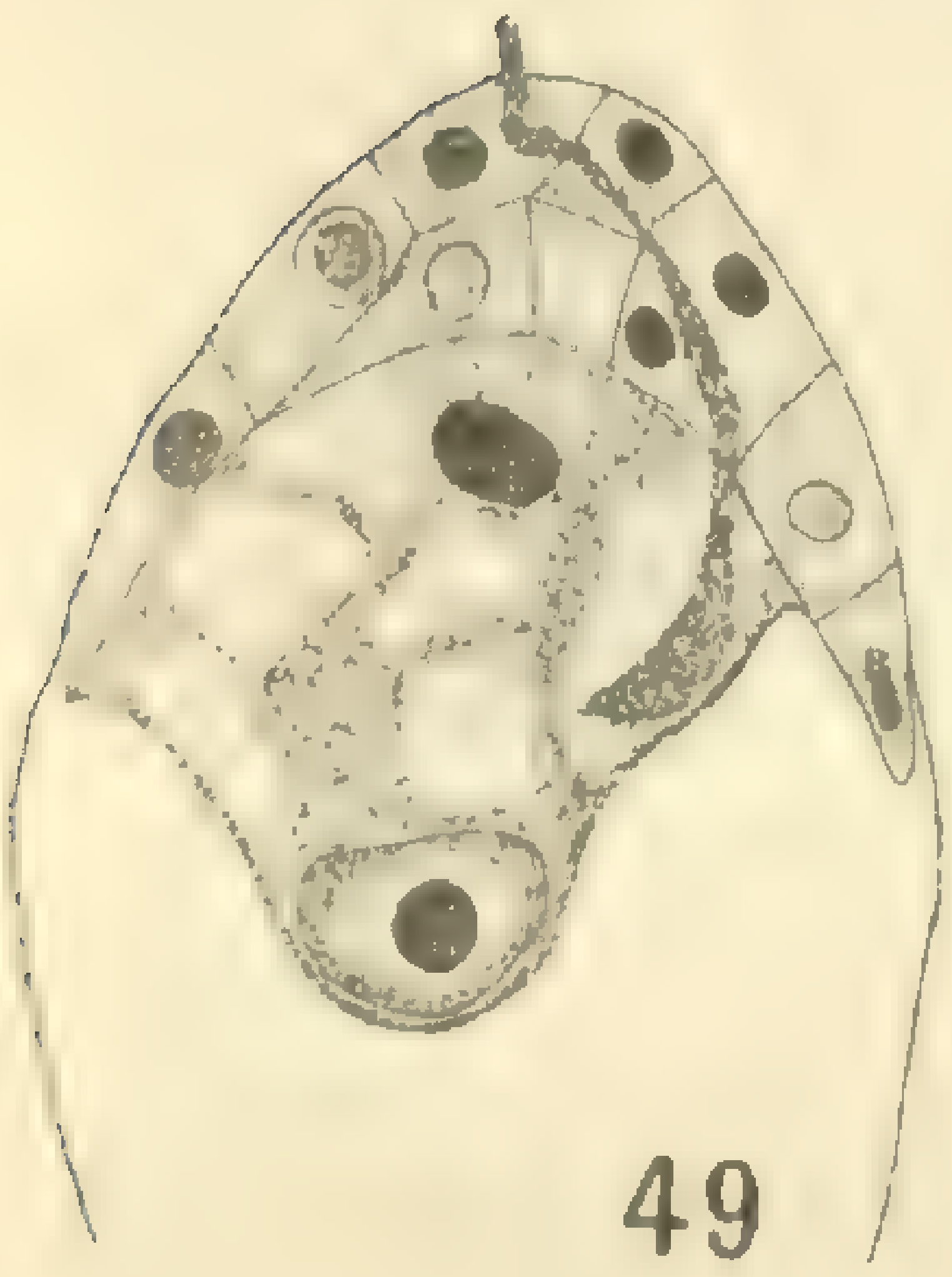
FIG. 53. Sac in which egg apparatus is formed; probably polar nuclei below egg apparatus. × 1375.

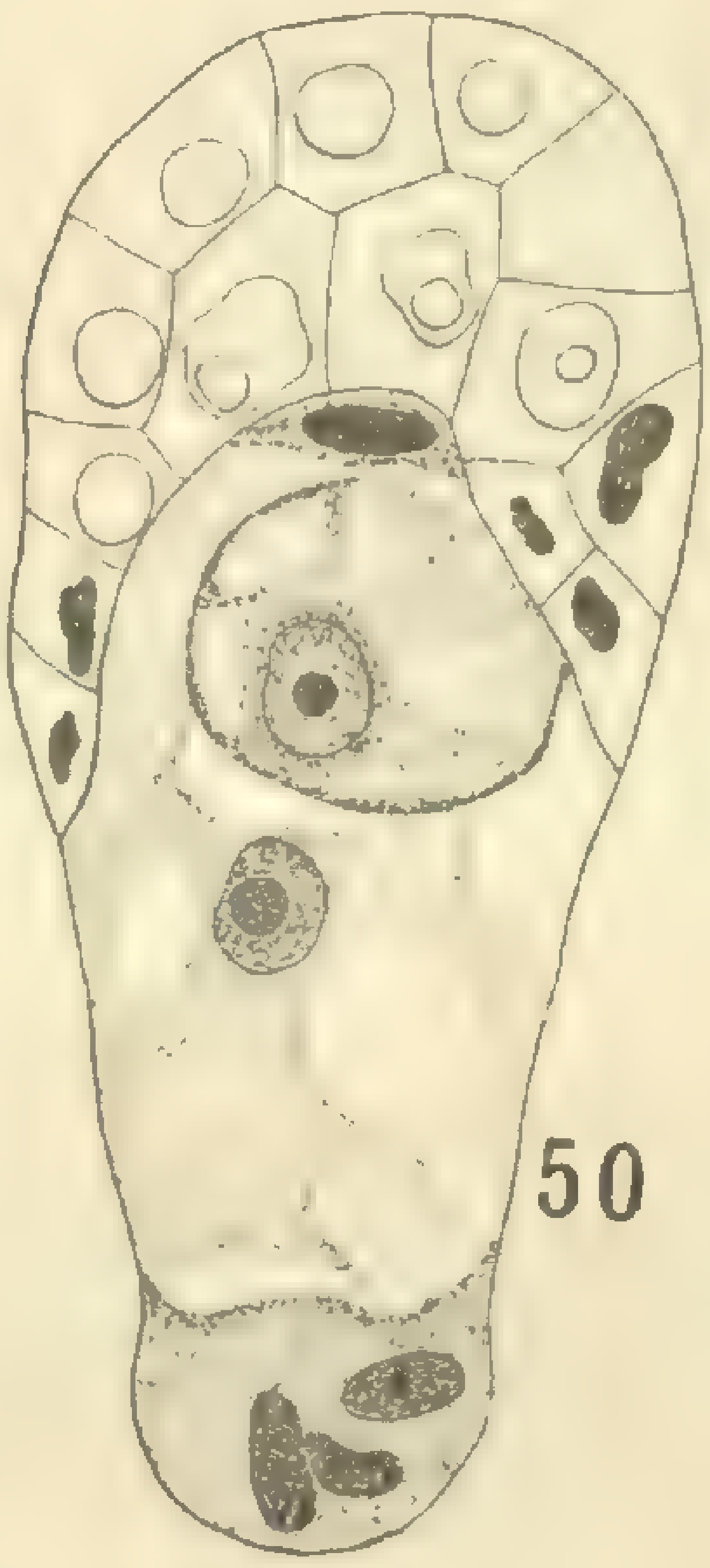
FIG. 54. Sac with egg apparatus and pollen tube. × 1375.

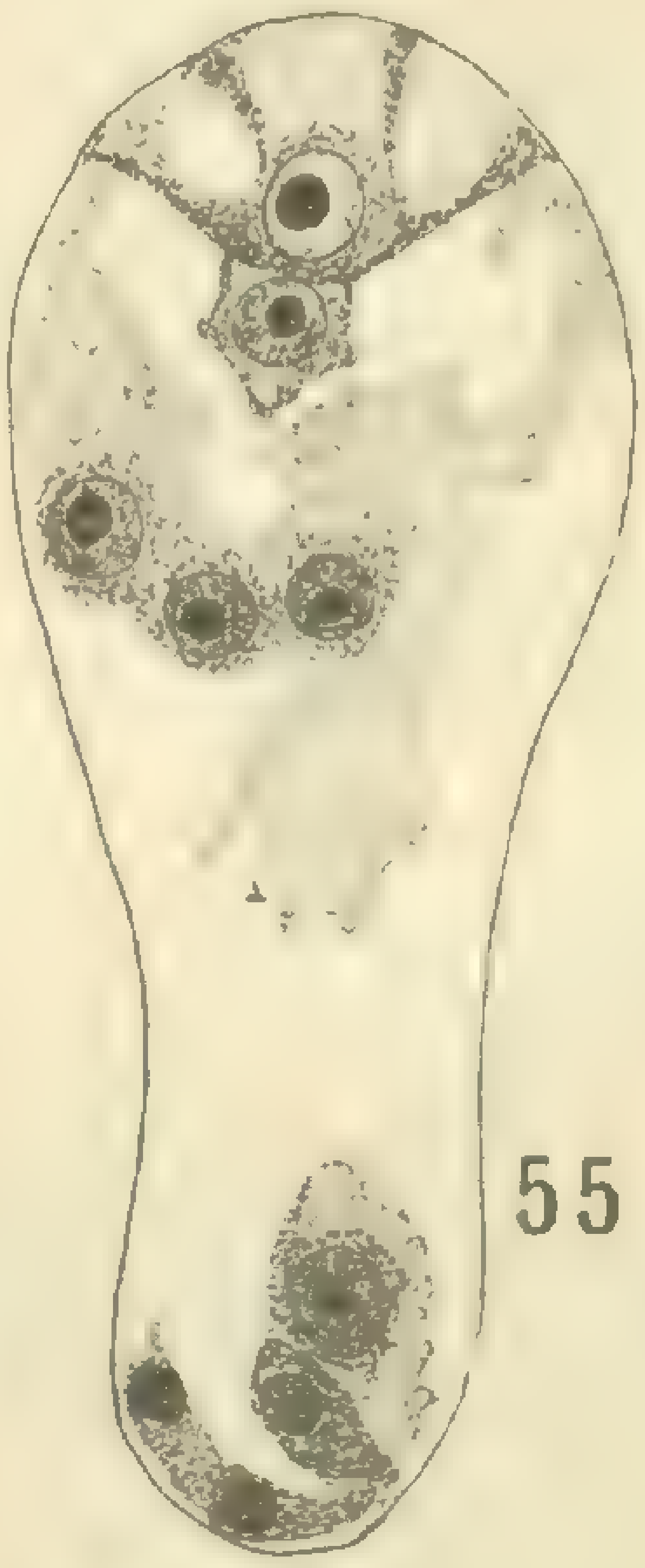
Up to this point the sequence is quite regular, but later there appear many irregularities of such a nature as to indicate general unfavorable conditions for normal development. Although after prolonged search I succeeded in finding preparations showing the usual behavior of the angiosperm embryo sac, these preparations constituted a very small part of those which should be considered in studying the real conditions of the embryo sac of *L. minor.* It is only exceptional cases in which sacs beyond the one-celled stage do not give some evidence of disorganization. The sections selected for drawing do not fully represent these conditions, since they were selected to illustrate normal as well as abnormal occurrences.

In *fig. 51* is shown a sac in the two-celled stage, in which the micropylar nucleus is normal, while the antipodal nucleus is disintegrating. Both nuclei may again divide, forming the four-celled sac (*fig. 52*), and each of these may divide in the normal manner. It is quite common to have the micropylar nuclei develop normally, while the antipodal nuclei disintegrate (*figs.* *42, 46, 51, 53, 54*).

The polar nuclei may fuse to form the primary endosperm nucleus (*figs. 46, 48, 50*); or they may fail to meet (*fig. 55*), in which case the upper polar nucleus seems to have been able to form endosperm cells without the assistance of the lower one. I was not able to determine whether the two cells below the egg apparatus in *fig. 53* are endosperm cells or polar nuclei. An interesting case is shown in *fig. 56*, in which the upper cell is probably an oospore, while below it are five cells, evidently endosperm cells. In the antipodal end of the sac are the remains of the antipodals, and immediately above them two very large cells which have the cytoplasm somewhat definitely organized. They do not stain as disintegrating cells, but react in a manner quite different from the five cells above them. I am not able to speak confidently in reference to these cells, but it is quite possible that they may have resulted from the division of the lower polar nucleus, while the five cells above may be the progeny of the upper polar nucleus.







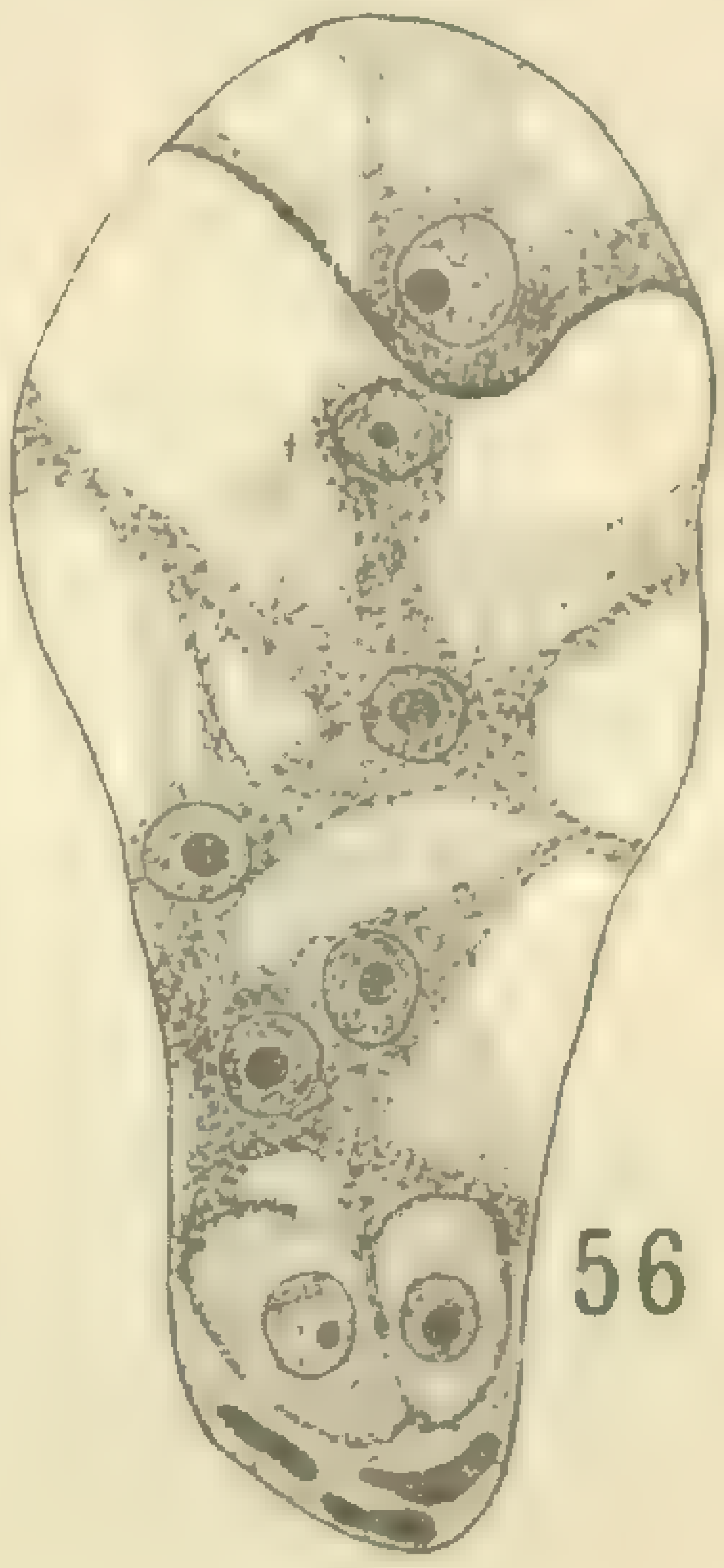


FIG. 49. Micropylar end of sac; recently formed oospore; part of pollen tube in sac and nucellus. × 1375.

FIG. 50. Sac with unusually large oospore. × 1375.

FIG. 55. Sac with oospore, endosperm, and antipodals; lower polar nucleus with antipodals. × 1375.

FIG. 56. Same as *fig. 55*, except the peculiar cells with the antipodals which may have come from division of lower polar nucleus. × 1375.

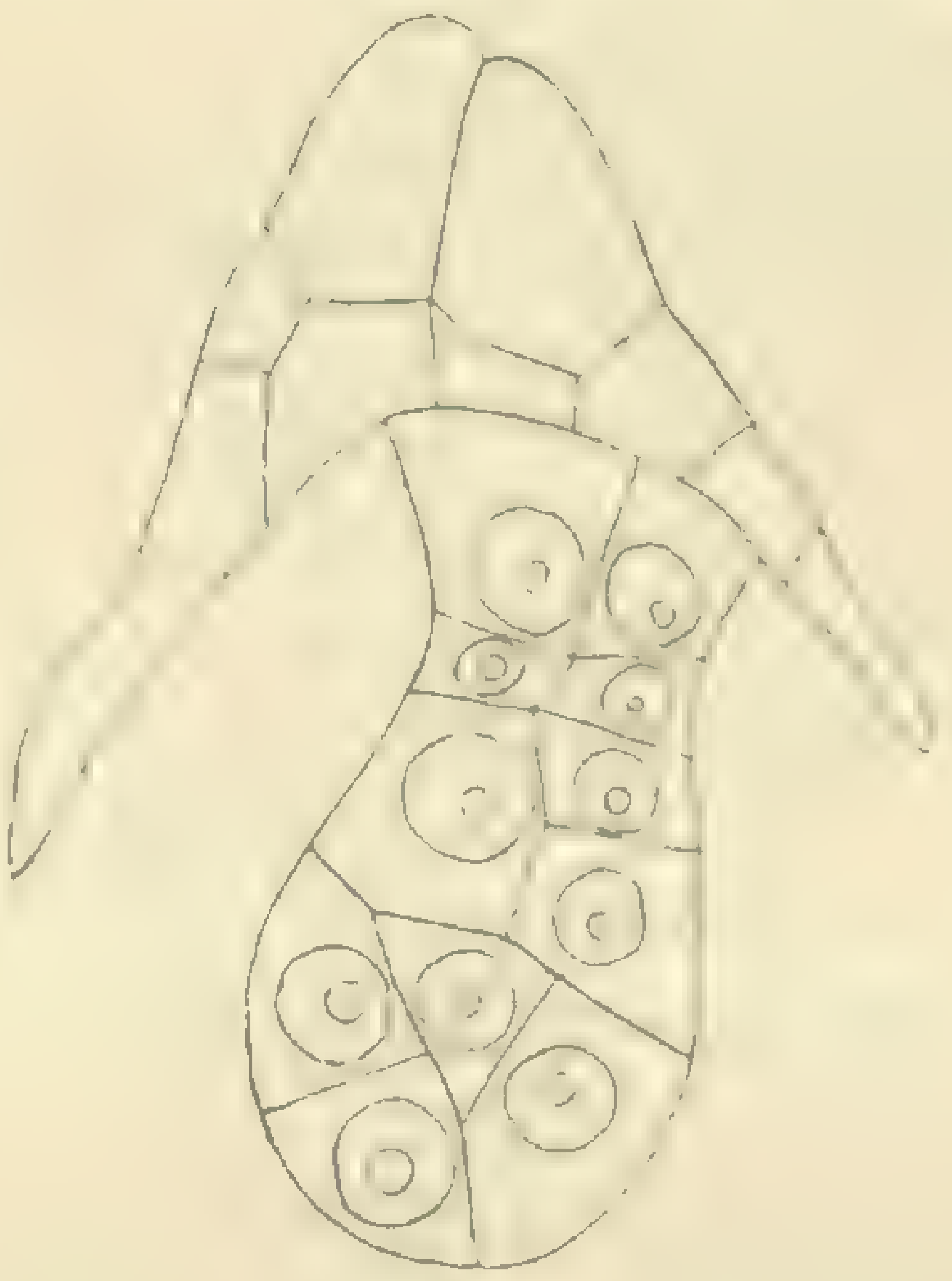
Similar behavior is reported for *Allium tricoccum* (**19**) and *A. Canadense* (**19**), in which of 170 embryo sacs examined at stages which should show antipodals they were found in but forty-five, there being in some of these but one or two of the cells present, and these very small and irregularly crowded together. Of these 170 sacs the egg apparatus was found in 165, and later stages examined showed normal embryos. A very large number of older ovules of *A. cernuum* was examined, there being but six embryos found.

FERTILIZATION AND FORMATION OF EMBRYO.

A very small per cent. of the female gametophytes succeed in developing oospheres and persisting until fertilization occurs, for, as has been stated, disorganization most often occurs before the egg apparatus is complete. The succession of regions as disorganization proceeds is noteworthy. Disorganization first affects the antipodals and may proceed no further, a condition of things very common among angiosperms; it may advance to the polar nuclei or endosperm and stop there; or it may involve the egg apparatus, which is the last to succumb. This process often involves the entire ovule to such an extent that it has almost disappeared when under ordinary conditions oospores would be found.

A sufficient number of cases were found, however, to show that fertilization and embryos may occur. In one case the pollen tube was seen to have penetrated the sac, and extended almost to the oosphere (*fig. 54*), and in *fig. 49* the remnants of the tube appear while the sex cells have just fused. An abnormally large oospore, which almost fills the micropylar end of the sac, is shown in *fig. 50*. Other oospores are shown in *figs. 48, 55, 56*. It is quite evident that many more oospheres are formed than are fertilized.

I was unable to make a sufficiently full investigation of the development of the embryo to justify any definite conclusions. The embryos shown in *figs. 57* and *58* do not show the form supposed to be typical for monocotyledons, as given in Alisma (**5** and **13** and Lilæa (18). But, as in *Lilium Philadelphicum* (15), the suspensor cells have divided by longitudinal walls and no definite embryo cell or cells can be distinguished. It is quite evident that there is more of a suspensor than is shown for this species in Hegelmaier's *Monograph* in his *figs. 3, 4, 5*. Other figures by Hegelmaier represent young embryos of this species as each having a very large terminal cotyledon, with the small plumule arising laterally near the suspensor region.



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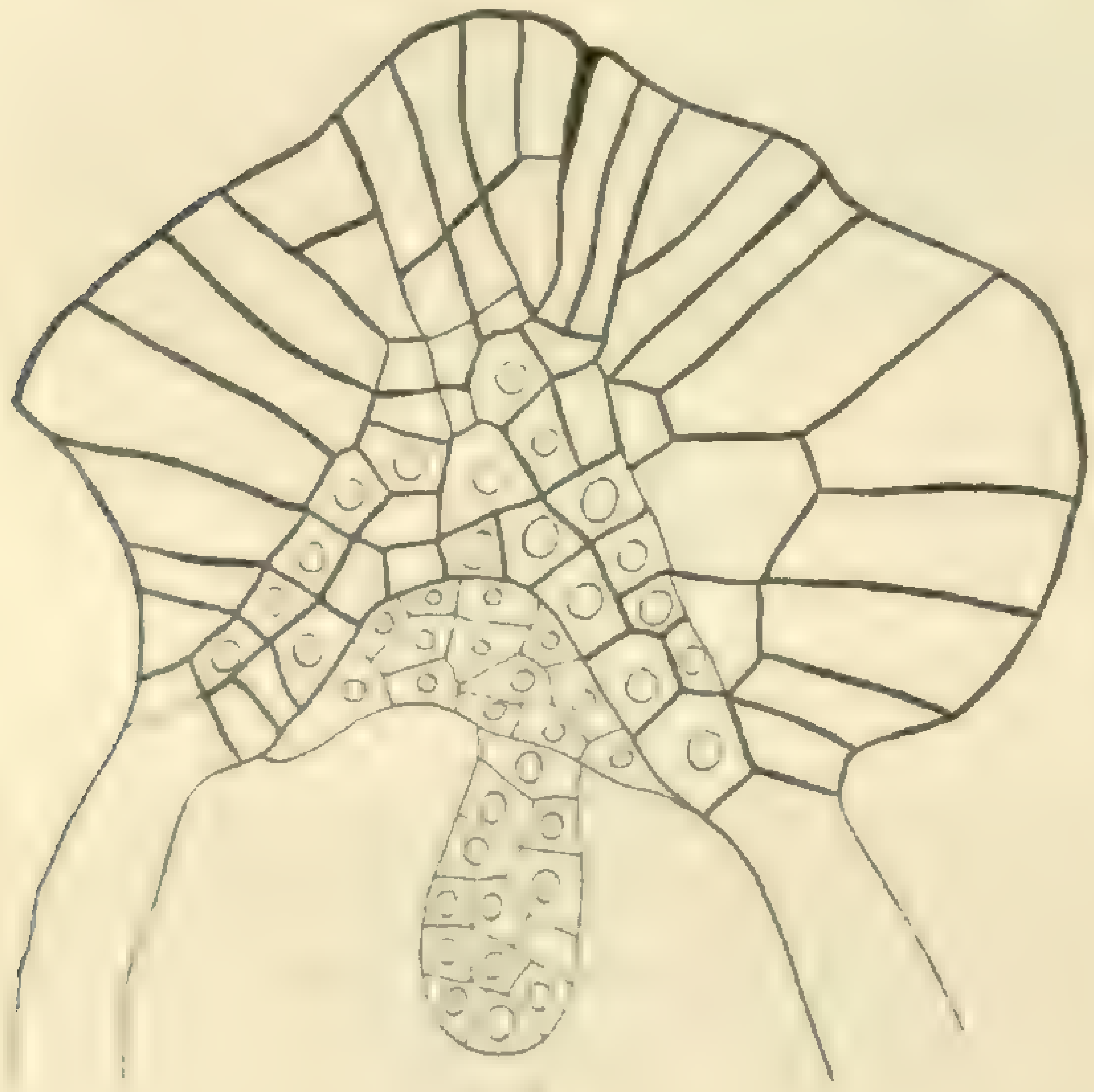
After fertilization the cells at the tips of the integuments enlarge and divide (*fig. 59*), crowding close together until there is a compact tissue of heavy-walled cells completely closing the micropyle (*fig. 57*), forming the so-called beak or operculum of germinating seeds. In no case where fertilization was not accomplished was such a structure seen



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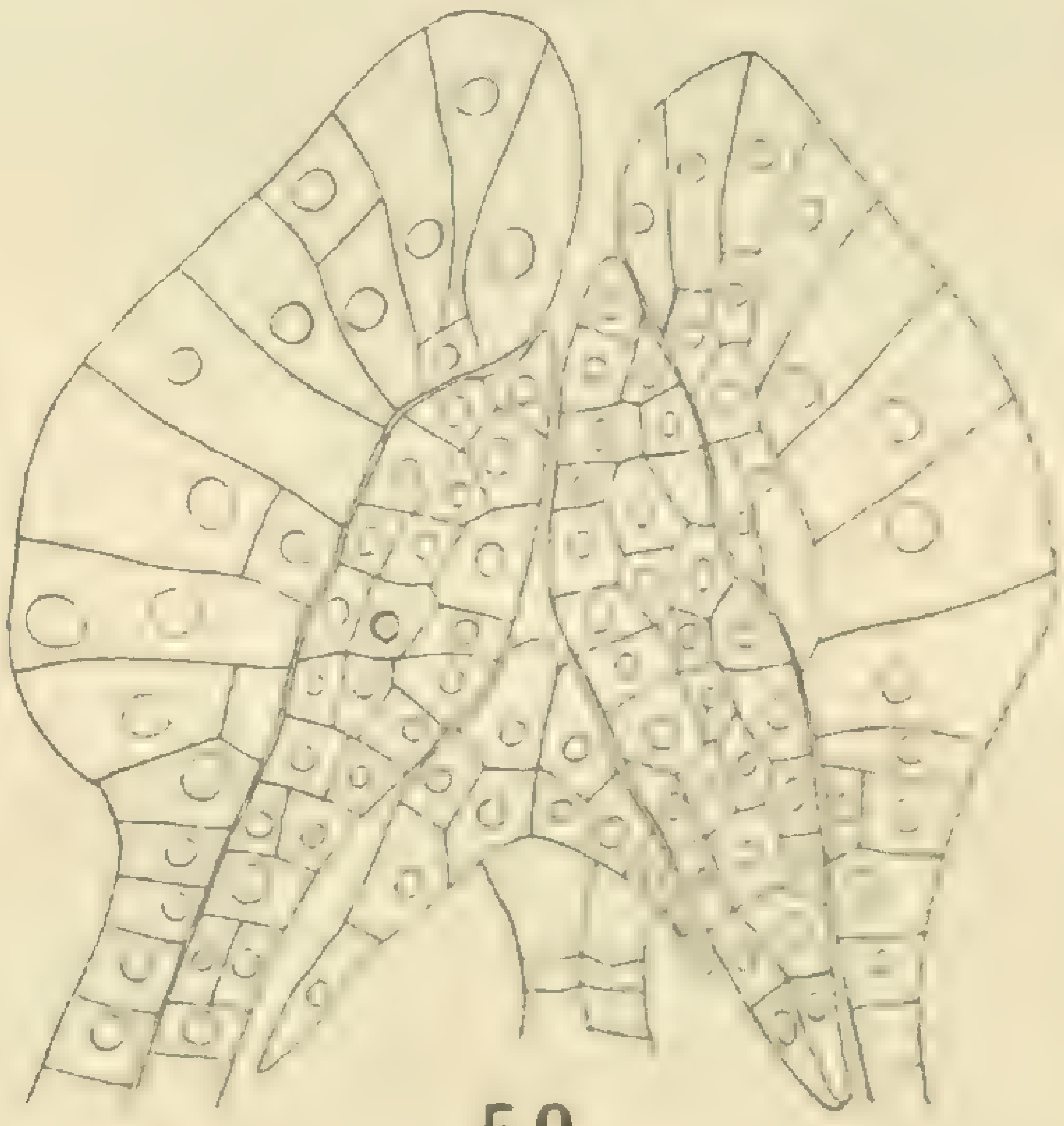

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FIG. 57. Embryo, nucellus, and the peculiarly thickened tips of the integuments. × 760.

FIG. 58. Young embryo attached to the nucellus; the base of the same embryo is shown in *fig. 59*. × 1375.

FIG. 59. Tips of integuments, the cells of which are enlarged; the nucellus and lower end of the embryo. × 760.

In undertaking this investigation I had hoped to find abundant embryos and germinating seeds, in order to determine the comparative morphology of the parts of the plant. But as few were found I can make little addition to the statements of other writers. When the seed coats burst the cotyledon appears first, and is so folded that it encloses the young stem. An absorbing organ remains in contact with the food material of the seed. The basal and nodal regions of the shoot soon become differentiated, and quite early there are developed the pouches in which are the new vegetative fronds. The energy of the plant now seems to be directed toward this new frond rather than to the embryonic organs, since all of the latter very soon disappear.

ECOLOGICAL NOTES.

In this connection I need but to mention the numerous large air spaces for aeration and floating, and the chloroplastids which have such great power of adjusting themselves to the light, to recall two prominent ecological adaptations of this plant.

Water and pollination.— It will be remembered that most water plants, *e. g.*, Naias, Vallisneria, and Elodea, have adaptations for securing pollination which are especially suited to their water environment, while the structures of the ovule, so far as reported, are rather normal. In Lemna we seem to have a plant which has exchanged a land for a water habitat, and in so doing has not succeeded in working out such effective devices for pollination as have the real water plants. This might add additional testimony in favor of the view that lemnas are derived from terrestrial forms. The terrestrial method of pollination seems to have proved almost a failure in the new conditions, and this may be the ultimate cause for the more or less complete disorganization of the structures of the embryo sac.

Winter buds.—There has been much discussion with reference to the winter buds, the usual idea being that they are morphologically different from the summer buds, but I have not been able to detect any striking differences. In the winter buds the air spaces are not abundant, and the bud is more nearly spherical. It must be borne in mind, however, that winter buds are formed only when the environment is becoming unfavorable. For this reason fewer air spaces are developed, and the cells do not divide so as to increase the bud in length. The greater rotundity of the winter bud, therefore, is not due to increase in thickness, but rather to decreased length, as compared with the ordinary summer buds. Since few air spaces are developed and gases are no longer actively produced, when the bud becomes free it sinks to the bottom of the pond or stream, or remains suspended in the water a little above the bottom. When the conditions again become favorable the bud begins to grow while in the winter position, and soon produces sufficient air spaces and gases to cause it to come to the surface of the water. By this time it has usually begun one or two new vegetative fronds.

My observations do not indicate that winter buds necessarily follow the production of flowers as stated by Guppy (**10**). A large number of cases were observed in which the usual summer frond develops at the same time that the flower is formed, or immediately afterwards. Hegelmaier doubts whether winter buds are ever formed in the tropics.

Flowers.—The ecological significance of the conditions of the flower of *Lemna minor* is very suggestive. It is known that flowers are developed very infrequently, and when one considers that in most of those formed the embryo sac structures and ovules break down at various stages in their development, resulting in great paucity of seeds, it becomes evident that the conditions which favor vegetative multiplication have led to great reduction of ordinary seed formation. The device of winter buds also greatly assists the plant in discontinuing the seed habit.

SUMMARY.

1. The sporophyte of *Lemna minor* cannot be definitely homologized with either a stem or a leaf, but is a shoot undifferentiated except at the basal and nodal regions.

2. The secondary root is formed from a group of hypodermal

cells at the node. The epidermis, which is pushed out, persists for a considerable time as the temporary root-sheath. The root-cap while young adheres to the main body of the root, but later becomes entirely free except at the growing point. The number of cells constituting the meristem region is unusually small, sometimes being reduced to one or two. An axial strand of undifferentiated cells is the representative of the conducting system of the root.

3. Flowers are rarely formed, and when present part or all of their organs may disorganize at any stage in their development.

4. In young flowers the nucellus and stamen papilla first appear, and about the nucellus is the beginning of the carpel. The spathe appears outside of the carpel and stamen papilla. The two stamens arise from the branching of the papilla.

5. A single archesporial mass appears in each stamen. This is later divided into two, then into four masses, constituting the archesporial masses of the four loculi of the anther, which four loculi constitute one and not four sporangia.

6. The primary tapetal layer is not cut off at the first division of the archesporial cells, but after these have become separated into four regions.

7. It seems clear that the tapetum is not a morphological but a physiological layer.

8. After the microspore mother cells have become free the cells of the tapetum frequently divide, pushing into the cavity of the loculus.

9. Many microspore mother cells disintegrate and function as tapetal cells.

10. The microspores germinate within the sporangium. The generative cell remains closely applied to the wall of the spore for a time before dividing.

11. In the megasporangium the primary tapetal cell usually undergoes no further division, while the primary sporogenous cell passes directly over into the megaspore.

12. Normal embryo sac structures are developed in com-

paratively few cases, the rule being that disorganization stops the process at some stage. This disorganization first affects the antipodal end of the sac. In sacs which have succeeded in developing endosperm we find it next attacked; and last to succumb to unfavorable conditions is the egg apparatus.

13. In case the polar nuclei fail to fuse one or both of them may develop endosperm without fusion.

14. Owing to the above conditions there is great paucity of seeds, not enough having been found to determine the homologies of the sporophyte.

15. The winter buds are summer buds which have failed to develop sufficient air spaces and gases to float them, and hence sink. When conditions become favorable again such are developed and they again come to the surface.

16. *L. minor* seems to have descended from terrestrial forms, and has not succeeded in adjusting to a water environment the processes involved in developing seeds.

In closing I wish to express my thanks to Dr. John M. Coulter and Dr. Charles J. Chamberlain for many valuable suggestions and criticisms given during the progress of this work.

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BRIEFER ARTICLES.

ADDITIONAL HOST PLANTS OF PLASMOPARA CUBENSIS.

In view of the fact that no certain information is at hand concerning the original host of *Plasmopara Cubensis* (B. & C.) Humph., except that it was a cucurbitaceous plant from Cuba, some interest may attach to an enumeration of the many new host species of the order Cucurbitaceæ upon which it has been collected about Wooster during 1898. While preparing for a study of this fungus in the extensive cucumber pickle fields of this county (Wayne) in which it had been signally destructive in 1897, the writer secured seeds of most of the usual species of the order and planted them, together with the cultivated varieties of cucumbers, muskmelons, watermelons, pumpkins, gourds, and squashes, in the pathological garden of the Ohio Experiment Station. The species represented the genera Micrampelis, Sicyos, Abobra, Melothria, Cucurbita, Momordica, Cucumis, Lagenaria, Benincasa, Coccinea, Trichosanthes, Bryonopsis, Cyclanthera, and Mukia, according to the seedsman's classification. A Madeira vine, *Boussingaultia baselloides*, was planted with the others. Unfortunately the seeds of Sicyos, Micrampelis, *Cucumis perennis* and *Momordica elaterium* did not germinate, and the plants of *Abobra viridiflora* and *Cucumis grossulariæformis* perished before midsummer. Plants of *Micrampelis lobata* (Michx.) and *Sicyos angulatus* L. growing along streams by diseased cucumber fields were attacked by *Plasmopara Cubensis*, the former very extensively, the latter quite rarely. As for the assembled cucurbits, all the surviving species except *Benincasa cerifera* and *Cyclanthera explodens* were more or less freely attacked by the same fungus.

The Wayne county host plants for *Plasmopara Cubensis* are accordingly :

Cucumis sativus, *C. Melo*, *C. odoratissimus*, *C. erinaceus*, *Cucurbita pepo*, *C. Melopepo*, *C. verrucosa* (?), *Citrullus vulgaris*, *Lagenaria vulgaris*, *Coccinea Indica*, *Bryonopsis laciniosa erythrocarpa*, *Mukia scabrella*, *Momordica balsamina*, *M. charantia*, *Melothria scabra*, *Trichosanthes colubrina*, *Sicyos angulatus*, and *Micrampelis* (*Echinocystis*) *lobata* ; not

Benincasa cerifera or *Cyclanthera explodens.* This Plasmopara has previously been reported upon five of the above named hosts, and upon *Cucumis Anguria* and *Cucumis moschata*;[1] its appearance upon so large a number of new hosts has added interest to this part of the study. In every case the cucumbers and muskmelons were first attacked, then the other cucurbits. No plant outside the order has as yet been attacked by this Plasmopara and no oospores have been discovered here either for *Plasmopara Cubensis* or *Plasmopara australis* (Speg.), which was found in abundance on *Sicyos angulatus* and sparingly upon adjoining plants of *Micrampelis lobata* adjacent to a diseased pickle field. It may be further observed, that *Plasmopara Cubensis* (B. & C.) is clearly distinct from *Plasmopara australis* (Speg.) whether examined upon the same hosts (Micrampelis and Sicyos) or upon the different hosts of the former.

I shall be pleased to supply, as far as possible, to any mycologists who may desire them, specimens of these fungi upon the various hosts.—A. D. SELBY, *Ohio Agricultural Experiment Station, Wooster, Ohio.*

COPPER IN PLANTS.

COPPER is an element of very wide distribution in the bodies of plants, a matter which appears to be determined by the presence of the metal in the soil rather than by the exercise of any selective power. Specimens grown in ordinary soils may contain as much as 30^{mg} of this substance to each kilogram of dry matter, while those in rich soils may yield 560^{mg} from the same quantity of dry matter according to Lehman.[2] The wood of a tree, *Quercus macrocarpa* Michx., recently submitted to Professor Frankforter of this university for chemical analysis, was found to contain slightly less than 500^{mg} of copper to each kilo of dry matter. When the matter was called to the attention of the writer, the entire trunk and crown of the tree had been carried away, with the exception of a short stump from which the bark had been stripped. This rendered impossible any attempt to determine the distribution of the substance throughout the plant. It was evident, however, that it was dead before it had been cut down. The examination of the material at hand showed the copper in the form of finely divided reddish-brown particles in the tracheides, vessels, and medullary parenchyma. It is presumed that it gained entrance to these tissues before the death of the tree and had therefore passed through the conducting elements and been absorbed by the living cells of the medullary rays. This tissue also contained starch both in the cells containing copper and those free from it. It is not easy to predicate in what form the copper was taken up by the plant, but probably as a carbonate, which would be reduced to the metallic state in the tissues. The large amount of the substance present rather supports Lehman's conclusions that it does not exert a marked injurious influence upon plants. Its occurrence throughout the annual rings indicates that it had been freely absorbed during nearly a decade. However, the death of the tree may have been finally caused by the influence of this substance.

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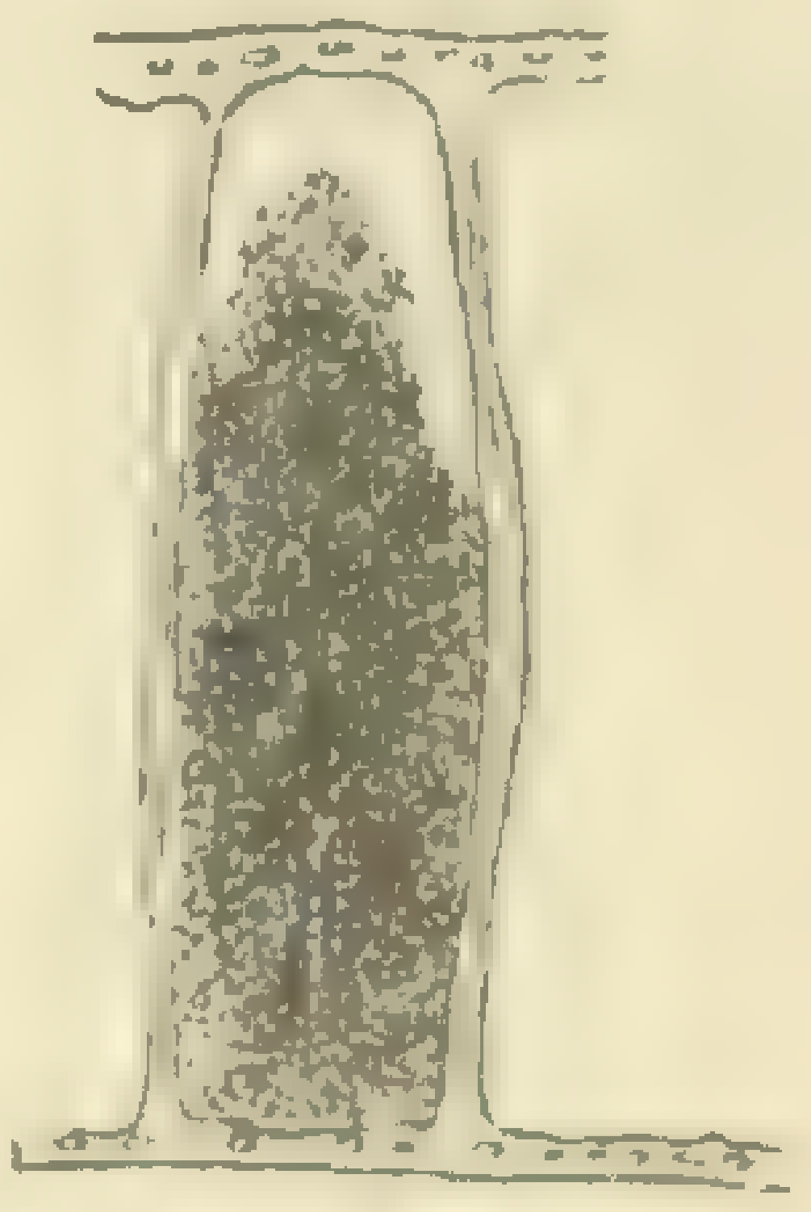
[1] Stewart, Bull. N. Y. Expt. Station.

[2] Der Kupfergehalt von Pflanzen und Thieren in kupferreichen Gegenden. Archiv fur Hygiene **27**: 1. 1896.



Medullary cell of *Quercus macrocarpa*, containing particles of metallic copper.

Mr. J. B. Skertchly has found that *Polycarpæa spirostylis* F. von Mueller occurs in such close connection with the copper deposits of North Queensland in such an invariable manner that it may be used as indication of copper deposits in the soil or in solution in the streams near by. On this account he has named it the "copper plant," and notes also that in regions rich in copper it is the predominant member of the herbaceous flora.[3] It is of interest in this connection to note that Lehman found that the tissues of fowls feeding in regions rich in copper yielded 15.5–115$^{\mathrm{mg}}$ of this substance per kilo of dry matter. An investigation of the plants growing in the copper regions around Lake Superior, and near the dumping grounds of cities, would doubtless bring some interesting results as to the absorption of metals.—D. T. MacDougal, *University of Minnesota.*

FROST FORMATIONS.

The purpose of this note is to collect the records of observations of frost formations on plants not included in my résumé in this journal.[4]

A letter from Professor Trelease dated April 7, 1894 states that he had observed the formation of crystals of ice on *Verbesina Virginica* at Bismarck, Missouri, in November of the previous year. He notes that "the air was rather moist. Temperature below freezing point in the shade. Soil moist. Plants recently dead. Plates (crystals of ice) noted about 2 to 5 P.M. on plants in shade — as though formed over night and melted elsewhere. At the same time similar crystals were seen on the soil and pebbles along paths."

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[3] Tin Mines of Watsonville, Rep. by J. B. Skertchly, Assistant Geologist, Queensland. 1897.

[4] **19**: 120. 1894.

Mr. F. E. Hand has observed the frost ribbons on *Cunila Mariana* in Kentucky.[5]

Mr. Valerio described the occurrence of such formations in Alabama as follows.[6]

> On January 27 the minimum temperature at this station was 14°. The next morning, going down the hillside by my house I noticed, on the dry grass and low brush, what at first sight I took for snow and nearer for bunches of cotton, but which on closer examination I found to be frostwork of a very peculiar shape and form, looking very much like fine stick or ribbon candy, or fine Venetian glass. These ribbons, beautifully curled and feather-like, came out from the stubs of the plants and, from a sample which I inclose, you will notice the bark was taken off the plants. The width of the frost ribbon was as the length of the cracks in the plant. They looked like fine shavings of a very white wood and crumbled at the touch.

Dr. Cleveland Abbe says concerning the formation of ice columns on soils:[7] "It is undoubtedly not only very common in our latitudes and soils, but is also quite an important item in agricultural soil physics." The formation of such crystals on the surface of the soil is due primarily to the freezing of the upper portion of the hygroscopic water on the soil particles and its elevation by the successive films of liquid water which replace it. A very ingenious and delicate experiment is suggested in imitation of this action. In regard to frost crystals on plants Dr. Abbe says: "When the outer air is frosty, while the sap is pressing up the body of the tree, a thin film of moisture may possibly be supplied from within as fast as the outer film at the surface of the crack may be frozen and lifted, and may thus form the exudation from the trees."

The notes given above establish quite clearly that the frost crystals which appear to exude from the tissues of dead plants are due to physical conditions quite similar to those found in soils, and to be in no way connected with the activity of protoplasm. The well-known power of dead roots to take quantities of water would furnish the necessary supply of this liquid. That ice crystals can be formed elsewhere and almost anywhere in or on living woody plants has often been demonstrated, but such phenomena ensue under conditions differing widely from those offered by the soil or dead herbaceous plants. D. T. MACDOUGAL, *University of Minnesota.*

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[5] Monthly Weath. Rev. July 1897.

[6] Rep. Climate and Crop Service, Jan. 1895.

[7] Am. Meteor. Jour. 9:523. 1893.

ANOTHER STATION FOR THOREA RAMOSISSIMA.

ON October 1, 1898, Mr. A. A. Hunter, collector for the botanical laboratory of the University of Nebraska, was fortunate enough to find good specimens of the curious and apparently rare alga *Thorea ramosissima* Bory, in Rock creek, a small stream near Lincoln, Nebraska. The plants were floating a little beneath the surface, along with other algæ, in swift-running water. Enough material was obtained for a thorough study of the structure of the free-floating part of the plant, and these have since been kept alive and growing in aquaria in the University plant houses. No specimens of the basal disk[8] have yet been secured, but as the station is not difficult of access it is hoped that these may be obtained next season, and the sexual organs studied. A preliminary paper is now in preparation by Mr. Hunter and G. G. Hedgcock, in which what is known of its structure and distribution will be discussed.— CHARLES E. BESSEY, *The University of Nebraska.*

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[8] *Haftscheibe* or *Fuss* of Schmidle. Hedwigia **35**: 3. 1896.

CURRENT LITERATURE.

BOOK REVIEWS.

The African flora.

IN VARIOUS European botanical centers the flora of Africa is receiving special attention, and what are called "novelties" are being published with bewildering rapidity. At Berlin, under the direction of Professor Engler, the publication of such work was begun in 1892 in the issues of the Royal Botanical Museums and Botanical Gardens. The time has come, however, to organize the results in some way, so that they may show more than lists of novelties. With this in view, Dr. Engler has arranged for a series of monographs, in which characteristic families and genera will be presented not only from the taxonomic standpoint, but also from that of their geographical distribution and economic value. As is to be expected under Dr. Engler's direction, geographical distribution does not have the narrow meaning it once had, but is largely ecological, bringing out not merely areas, but the relation of vegetation to them. The first two parts[1] are now before us, and text and plates both give promise of a magnificent series.

The Moraceæ are represented as follows: Morus (2 species), Chlorophora (2), Cardiogyne (1), Dorstenia (41, of which 11 are new), Trymatococcus (2), Mesogyne (2), Scyphosyce (2), Treculia (5), Artocarpus (2), Bosqueia (5), Myrianthus (6, of which 1 is new), Musanga (1), Cannabis (1). The African display of the group is also compared with its occurrence in tropical America and the East Indies. In conclusion the following facts are said to be evident:

(1) A striking relationship between the forest floras of Africa and tropical America; (2) a less striking relationship with the tropical Asiatic forest flora; (3) a somewhat important difference between the forest floras of east and west Africa; (4) a very evident difference between the Abyssinian forest flora and that of the rest of tropical Africa; (5) a transition and adaptation of the forest types to the steppes and deserts as well as to the mountains.

The Melastomaceæ are represented in Africa by twenty-three genera, the largest of which are Dissotis (51 species, 14 of which are new), Memecylon (35, with 22 new), Osbeckia (16, with 6 new), Tristemma (15, with 7 new),

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[1] Monographien afrikanischer Pflanzenfamilien und Gattungen herausgegeben von A. Engler.—I. ENGLER, A.: Moraceæ (excl. Ficus. 4to. pp. iv + 50. *pl. 15.* Wilhelm Engelmann: Leipzig. 1898. *M* 12.—II. GILG, E.: Melastomaceæ. 4to. pp. 52. *pl. 10.* Wilhelm Engelmann: Leipzig. 1898. *M* 10.

Calvoa (8, with one new), Amphiblemma (7). A new genus, Afzeliella, is described, founded upon *Guyonia ciliata* Hook., in addition to the seven new genera (Urotheca, Petalonema, Cincinnobotrys, Myrianthemum, Tetraphyllaster, Phæoneuron, and Orthogoneuron) described by the author in Engler's *Pflanzenfamilien*. In comparing the African representation of the family with its occurrence in other tropical regions, it is stated that the relationship to tropical America is hardly worth mentioning, while that to the East Indies is striking. This conclusion, taken in connection with that of Dr. Engler, mentioned above, in his study of the Moraceæ is especially interesting.—J. M. C.

Schwendener's collected works.

TWENTY YEARS ago Prof. Dr. Simon Schwendener was called to the University of Berlin. For some years he has cherished the wish to bring together his papers published in the *Berichte* and *Abhandlungen* of the Royal Prussian Academy of Sciences and occasionally in other places. This wish has now been realized in the publication of two octavo volumes of almost 900 pages.[2] The time is particularly opportune, because since January 1, 1898, separates of the publications in the Academy transactions have been made available to the book trade.

The papers, to the number of thirty-one, have been reprinted without change, except of typographical errors and mistakes in calculations. The place of original publication is also cited. We wish we could add that the original pagination was indicated, but this has unfortunately been overlooked or considered inadvisable. To a few of the papers the author has added brief supplementary remarks, either by way of defense or explanation.

The arrangement of the papers is according to subject and, within each category, chronological. The range of subjects is so great that we think it of enough interest to reproduce the list: Trajectoric curves; stomata; phyllotaxy; ascent of sap; swelling and double refraction; twining of plants; stability (*Festigkeit*) of plants; latex vessels; protective sheaths; pulvini. Besides these he has papers in collaboration with G. Krabbe on torsions of leaves and on the relation between turgor and growth. On each of these subjects there are from one to three papers, except on phyllotaxy which includes six.

Nothing need be said as to the contents of the volumes, for Schwendener's researches have already a high place in the esteem of his contemporaries. It is a matter of congratulation both for author and botanists that they have now been conveniently collected as have those of Sachs, Nägeli and Pringsheim.—C.R.B.

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[2] SCHWENDENER, S. Gesammelte botanische Mittheilungen. 8vo. Vol. I. pp. viii + 453. *figs. 15, pl. 11.* Vol. II. pp vi + 419. *figs. 8, pl. 15.* Berlin: Gebrüder Borntraeger. 1898. *M* 25.

NOTES FOR STUDENTS.

DR. LIUGI BUSCAGLIONI suggests the use of "Sudan III" in botanical microtechnique. It stains wax, cutin, and suberin intensely red, while cellulose membranes, collenchyma, gelatinous and lignified membranes remain uncolored. Of the cell contents the nucleus, nucleoli, protoplasm, starch grains and tannins remain unstained ; while fats, resins, and latex stain bright red, and the chloroplasts pale red.—C. R. B.

BRONISLAW DEBSKI[3] finds that during oogenesis in Chara there is no reduction in the number of chromosomes. After the breaking down of the nuclear membrane, but before the formation of the spindle, protoplasmic radiations may be seen around the nuclear cavity. Spindle development was not followed in detail, but Debski is inclined to think that it is at first multipolar. The cell plate arises from thickenings of the connecting fibers. In the nuclei of nearly all mature cells changes occur in the nucleoli and nuclear network. These changes lead to fragmentation of the nucleus and such cells are no longer capable of division. The cell wall in Characeæ shows no cellulose reaction with chlor-iodide of zinc or with iodine and sulfuric acid.

In a previous article Debski showed that no reduction in the number of chromosomes takes place during spermatogenesis in Chara.—CHARLES J. CHAMBERLAIN.

PARTHENOGENESIS in plants is, to say the least, a very rare phenomenon, *Chara crinita*, species of *Saprolegnia*, and perhaps *Marsilea Drummondii* furnishing the only fairly proven cases among cryptograms. In *Cœlebogyne ilicifolia*, formerly believed to be parthenogenetic, it is now known that the embryos developed from nucellar tissues and not from an unfertilized egg. Kerner assumed parthenogenesis in *Antennaria alpina* because pistillate plants developed seed when no staminate plants were in the vicinity. *Mercurialis annua* is also said to be parthenogenetic.

H. O. Juel[4] has made a careful survey of the embryology of *Antennaria alpina*. He reports that generally only pistillate plants are to be obtained, and even when staminate plants are found the pollen is either entirely lacking or feebly developed. The development of the embryo sac is normal up to the eight-celled stage. The antipodals continue to divide and form quite a tissue. The polar nuclei do not fuse, but each divides independently and contributes to the endosperm, so that, like the egg, they are capable of division without a previous fusion. This seems to be a perfectly proven case of parthenogenesis.—CHAS. J. CHAMBERLAIN.

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[3] Weitere Beobachtungen an Chara fragilis. Jahrb. f. wiss. Bot. **32**: 636–670. *11–12.* 1898.

[4] Bot. Centralbl. **74**: 369–372. 1898.

Items of taxonomic interest are as follows: A good figure of *Hypericum galioides* Lam. has been published in *Gardener's Chronicle* (III. **24** : 301. 1898).—*Beckwithia* is a new genus of Ranunculaceæ, described by W. L. Jepson (*Erythea* **6** : 97-99. 1898). The single species, *B. Austinæ*, is said to be so strikingly like *Viola Beckwithii* in habit as to have suggested a possible teratological form of that species. The affinities of the genus are uncertain, suggesting Anemone in general appearance, and Pæonia in its more technical characters. The flowers have not been seen. The plant was discovered in Modoc county, California.—John W. Harshberger has published (*Proc. Philad. Acad.* **1898** : 372-413) the results of his recent observations upon the Mexican flora, made mostly in the Valley of Mexico. A catalogue of species is given, with critical notes.— In the current *Bull. Torr. Bot. Club* (**25** : 561–565. 1898) George V. Nash has published a revision of *Triplasis*, a group of grasses frequently placed under Triodia. Three species are recognized, *T. purpurea*, *T. intermedia* (a new species), and *T. Americana*. In the same journal (580–582) A. A. Heller continues his presentation of new and interesting plants from western North America, including a new Hydrophyllum from Washington.—Janet R. Perkins has published (*Engler's bot. Jahrb.* **25** : 547–577. 1898) some of the results of her investigation of the Monimiaceæ. After a discussion of the general features and taxonomic characters of the group, the author presents a synopsis of the Mollinedieæ, including ten genera, five of which are proposed as new (*Macropeplus*, *Macrotorus*, *Steganthera*, *Anthobembix*, and *Tetrasynandra*.)— Under the title "Phycological Memoirs" DeAlton Saunders has begun a series of papers in *Proc. Calif. Acad. Sci.* (III. **1**: 147–168. 1898, with 21 lithograph plates). This first contribution considers "Some Pacific Coast Ectocarpaceæ," and "Sphacelariaceæ and Encœliaceæ of the Pacific Coast." Seven new species of *Ectocarpus* are described, also new species of *Sphacelaria*, *Scytosiphon*, and *Colpomenia*. A new genus of Encœliaceæ is described, founded on *Punctaria Winstonii* Ands., and named *Halorhipis* ("sea-fan")—J. M. C.

In celebration of the twenty-fifth anniversary of the doctorate of Dr. Melchoir Treub, director of the botanical garden at Buitenzorg, the publishers of the *Annales* of the garden have issued a supplement (pp. 167, *pl. 9*) containing twenty-three short papers prepared by some of those who have been accorded the privileges of the garden, both botanists and zoologists. Solms Laubach describes the development of the ovule and seed of Rafflesia and Brugmansia. Molisch discusses the bleeding of tropical trees in full leaf, the pressure in the night often exceeding two atmospheres. Haberlandt describes the movements of the leaves of Biophytum, and believes the transmission of impulses to be through plasma connections in the cells of the vascular bundles. Schiffner establishes a new genus of Hepaticæ, Wettsteinia, based on *Plagiochila inversa* Sande Lac., and *Tylimanthus scaber* Schiff. Karsten presents some new researches on the formation of auxospores in diatoms. Goebel shows that in all observed Muscineæ the wall of the antheridium is active in dehiscence, and is not merely ruptured by the swelling contents. Went points out a periodicity in the blooming of Dendrobium; Ewart has a general paper on physiological research in the tropics; Wiesner describes a new form of false dichotomy in the shoots of woody plants; Massart writes on epiphyllous plants, represented by algæ, lichens, hepatics, and mosses. Warburg emphasizes the antithesis between the tropical strand flora of America (incl. West Africa) and that of Asia (incl. East Africa). Boerlage describes the manner of floating and the germination of the fruits of *Heritiera littoralis*, a coast tree of all the Malayan islands. Kamienski describes a new terrestrial Utricularia which he dedicates to Treub under the name *U. Treubi*. Besides these there are several other botanical papers of less general interest.—C. R. B.

IN A PAPER just published[5] by Dr. R. H. True and C. G. Hunkel, on the poisonous effect exerted on living plants by phenols, the authors summarize their results as follows:

"We find, as far as our knowledge of the dissociation of the phenylic compounds permits us to draw conclusions, that, except in isolated instances electrolytic dissociation plays but a very subordinate rôle in determining the toxic properties of these substances. Picric and salicylic acids strongly dissociate and become powerfully poisonous by virtue of the H ions, in great measure. Pyrogallol and probably methyl salicylate first undergo other molecular changes, after which their products dissociate electrolytically. Here the H ions may account for much of the toxic action. In the cresols and mono-nitrophenols, electrolytic dissociation seems to exert a pronounced influence. Some phenols are comparatively weak in their integrity, but quickly change to substances containing constituents even more fatal than H ions. Pyrocatechol, and especially hydroquinone, are of this class.

"Certain radicles seem to have specific properties when introduced into the molecule, modifying the toxic value. The number of hydroxyl groups (OH) present seems to have little influence on the toxic action of the phenols. as in the series: benzophenol (1 OH), resorcinol (2 OH), and phloroglucin (3 OH). The introduction of the methyl group (CH_3) into the benzene nucleus increases the toxicity to a considerable, but rather variable, degree, as in the cresols, less plainly in orcinol. The introduction of the isopropyl group ($CH(CH_3)_2$) into the cresols increases the toxic value of these substances, as carvacrol and thymol. The presence of one or more nitro groups (NO_2) increases the toxic action to a great degree; *e. g.*, mono- and trinitrophenols. An increase in the number of the NO_2 groups present does not seem to increase the toxic action. When the H of an OH group is replaced by a CH_3 group, little influence seems to be exerted on the toxic action, *e. g.*, anisol and guaiacol. The carboxyl group (COOH) brings with it a degree of toxicity corresponding directly to the degree of dissociation and the number of H ions it affords, *e. g.*, salicylic acid."—C. R. B.

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[5] Botanisches Centralblatt **76**: — seqq. 1898.

MR. A. A. LAWSON[6] has investigated the earliest stages in the formation of the multipolar spindle in the pollen mother-cells of *Cobæa scandens*. The cytoplasm of the resting pollen mother-cell presents a clear uniform appearance, but as division approaches a zone a granular substance accumulates about the nucleus. This zone is so constant in Cobæa and other genera examined by the writer that he proposes to designate it by the term *perikaryoplasm*. The zone was observed in living cells and so could not be regarded as an artefact. When the nuclear membrane breaks down, the perikaryoplasm and the linin of the nucleus form a network of kinoplasmic fibers. These grow out into several projections and become the cones of the multipolar spindle. Spindle fibers are formed by the elongation of the meshes of the network. The cones elongate, become sharp pointed and fuse in two groups, thus forming a bipolar spindle. The mature spindle is characterized by the great length and crossing of the mantle fibers. Spindle formation in the second division of the pollen mother-cells is the same as in the first. No centrosomes were observed at any stage of the process.

Fleming's fluid was used for fixing, and the safranin-gentian violet-orange for staining. The reviewer would suggest that while these form a combination of unusual value, it would nevertheless be refreshing to find some other combination thoroughly perfected, especially since it has been claimed by competent observers that mixtures containing chromic acid precipitate certain of the liquid albuminoids of the tissues in the form of filaments or networks, which are often of great regularity and simulate structural elements of the tissues. If this objection is well founded, it applies with especial force to such problems as those concerning spindle formation.—CHARLES J. CHAMBERLAIN.

IN AN ARTICLE of some seventy pages,[7] Dr. Georg Klebs gives a detailed account of many ingenious and conclusive experiments regarding the nature of the sexual and asexual reproductive organs of *Sporodinia grandis*, and the causes which determine their occurrence.

Of the physical factors, those which heighten transpiration increase the tendency to the formation of sporangia. When transpiration is checked, within certain limits, the sporangia are partially replaced by zygotes, and when transpiration is still further checked, only zygotes are formed. Thus, with a relative humidity of 100 per cent. only zygotes are produced; at 45–

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[6] Proc. Cal. Acad. Sci. III, 1: 169–184. *pl. 33-36.* 1898.

[7] KLEBS, GEORG: — Zur Physiologie der Fortpflanzung einiger Pilze. Jahrbücher fur wiss. Bot. 32: 1. 1898.

65 per cent. sporangia only; below 40 or 42 per cent. the mycelium is sterile. But sporangia may be produced in a greater humidity if anything, *e. g.*, a current of air, promotes transpiration.

When the air pressure is reduced to 40 or 60^{mm} of mercury parthenogenesis results; below $20–25^{mm}$ no sex organs are formed, and below $15–20^{mm}$ no sporangia develop.

In discussing the food supply it is proved that carbohydrates are needed to form zygotes, while sporangia may be formed luxuriantly in nitrogenous media.

It is of interest to note that different isomerous compounds may behave differently. Thus maltose provides the food needed for zygote production while lactose does not. Unfortunately, stereoisomers were not investigated. The minimum concentration in which zygotes could be formed was determined; for this was shown to depend upon the concentration rather than upon the absolute quantity of food present. A small quantity of acid salt favored zygote building while normal salts and acids retard it. The author thinks the favorable substances increase the permeability of the protoplasm to nourishment.

Parthenogenesis in general results when conditions are suited to the production of sex organs and then change so as to restrict their functioning. It results with the greatest certainty when the plant grows in a reduced atmospheric pressure, *e. g.*, about 50^{mm}.

As a result of the work, the view of Brefeld, that the determination of the kind of organs to be produced comes from within, must be abandoned. Also the prevalent notion that zygotes are made in "hard times" finds little support, as in nearly every case their formation is more easily arrested than that of sporangia.

Since in luxuriant vegetative growth diminished humidity, permitting transpiration, results in the formation of sporangia, the latter may be regarded as shortened branches rendered fertile by the extra supply of nourishment at their disposal, or by some as yet unknown stimulus.

Sporangia and zygotes are morphologically homologous organs, developing from aerial hyphæ of the same construction. They are similar physiologically and can develop only in air. The stimulus which calls them forth is transpiration, but the optimum for each lies at a different point; higher for sporangia, lower for zygotes.

The fact that aerial hyphæ are subject to a molecular impact different from that on the submerged hyphæ may be a determining factor in the development of reproductive organs. Also the fact that submerged hyphæ may absorb nourishment osmotically through a great area while an aerial branch receives it through a relatively small cross section may account for some of the differences between aerial and submerged parts of fungi, and of higher plants as well. — F. L. STEVENS.

NEWS.

M. Fr. Gay, of the University of Montpelier, a well-known student of the green algæ, died recently at the age of 40 years.

Pastor Christian Kaurin, of Sande Jarlsberg, Norway, a well-known student of Scandinavian bryology, died on May 25, 1898, at the age of 66.

Professor T. Caruel, the eminent professor of botany and director of the botanic garden of Florence, died recently after a long and painful illness.

The French Academy of Science has awarded the Desmazières prize to our colleague, Professor J. B. DeToni, of the University of Padua, for his monumental work, the *Sylloge Algarum*.

At the annual meeting of the Royal Society (London) on Wednesday, November 30, a "Royal Medal" was awarded to Mr. Walter Gardiner in recognition of his discovery of the continuity of protoplasm.

Axel Blytt, professor of botany in the University of Christiania, died on July 18, 1898, at the age of 54 years. Since his death Professor Dr. N. Wille has been made director of the museum and herbarium of the University.

The Canadian government has appropriated £1400 for the establishment of a floating biological station in the Gulf of St. Lawrence. It is hoped that the work will be begun early in the present year, on the south shore of Prince Edward's island. The station will be moved annually. Among the directors we note the name of Dr. D. P. Penhallow, of McGill University.

Bryologists will be gratified to learn that the wish expressed in our review of M. Renauld's *Prodrome Flore bryologique de Madagascar* for illustrations of the new species described is to be gratified. MM. Renauld and Cardot are engaged to publish the mosses in the great work of M. Grandidier on Madagascar. Therein all the new species described in the *Prodrome* and many others will be figured on superb quarto plates. The first fascicle containing thirty-two plates has just appeared, to be followed by three and perhaps four others.

M. Michel Gandoger, the well-known author of the *Flora Europæ*, an octavo work of 27 volumes published at Paris 1832–1893, is about to dispose of the herbarium upon which this work was based. Where possible he will divide each specimen into two parts. One set of these is to be presented to the Museum at Paris; the other set will be sold. M. Gandoger has come to this decision in order to ensure the preservation of this valuable collection. In case an accident should befall one-half of it, the other will be likely to remain intact. His herbarium now contains 260,000 specimens, including a complete flora of Europe, and a considerable number of specimens of Africa, Asia, etc. All are in a good state of preservation and are poisoned either with corrosive sublimate or arsenate of sodium. We should be glad to know that some of our own larger herbaria had secured this important set of specimens. It would be particularly valuable in determining the identity of American with European forms.

AT THE MEETING of the Academy of Science of St. Louis on the evening of December 5, 1898, Mr. H. von Schrenk presented by title a paper "On the mode of dissemination of Usnea barbata;" and Professor L. H. Pammel presented by title a paper on "The histology of the caryopsis and endosperm of some grasses."

Dr. Theo. Kodis presented the results of some experiments on overcooling animal and vegetable tissues, in which it was shown that, as water may, under favorable conditions, be cooled to some distance below zero, Centigrade, without freezing—the temperature immediately rising to the freezing point the moment that freezing begins, and remaining there until the water is entirely solidified, then beginning once more to drop—so, when animal and vegetable tissues are experimented on, they may be cooled to a temperature decidedly lower than the freezing point, under favorable conditions, before freezing begins, but that, when it begins, the temperature at once rises to the freezing point (which is always somewhat lower than that of pure water), remaining there until the process of freezing is complete, when it once more begins to fall. The speaker gave a short account of the current theories as to the mechanical constitution of protoplasm, and discussed the bearing on them of the phenomena when the solidification of overcooled tissues began.—WM. TRELEASE.

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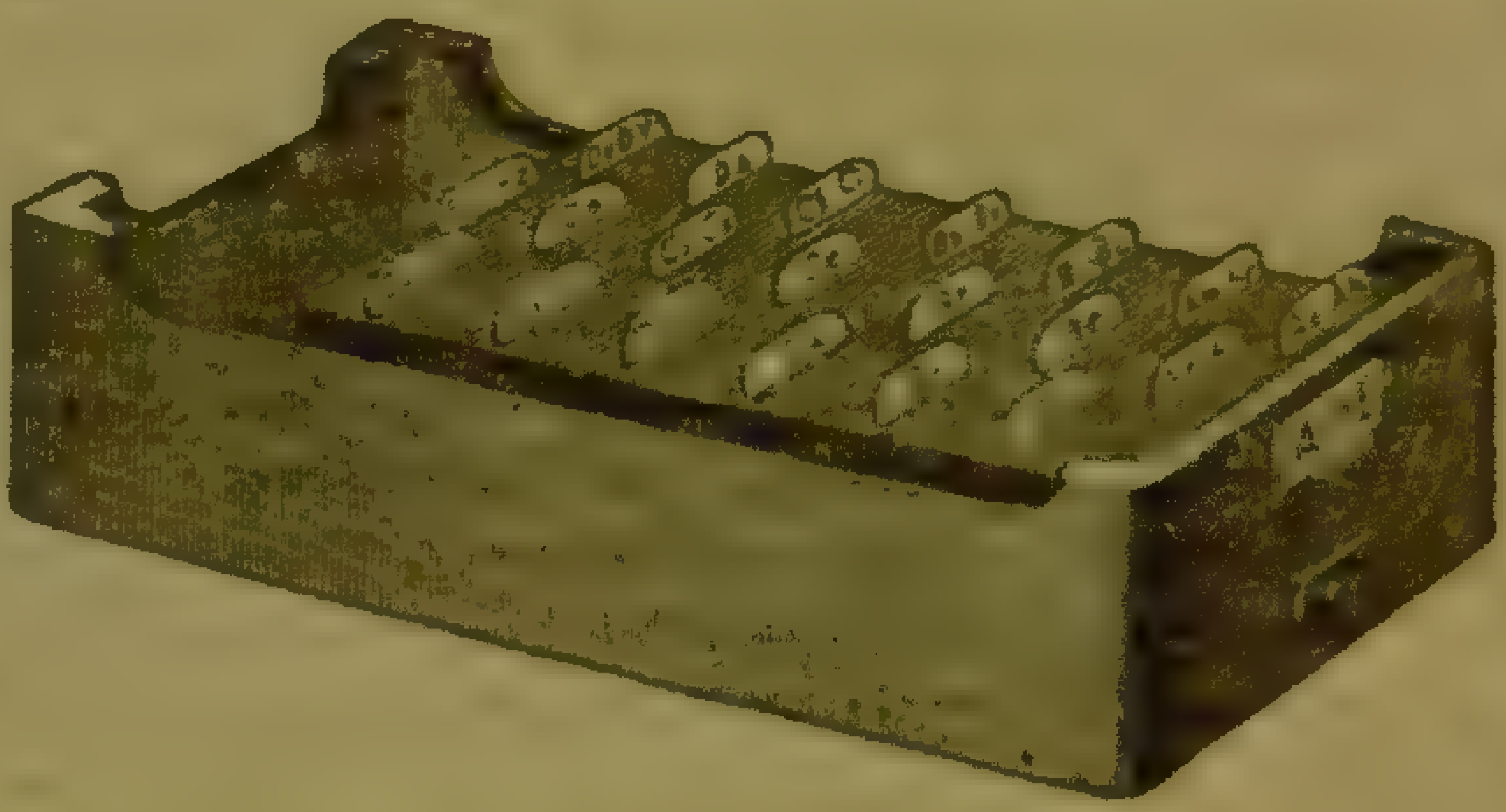

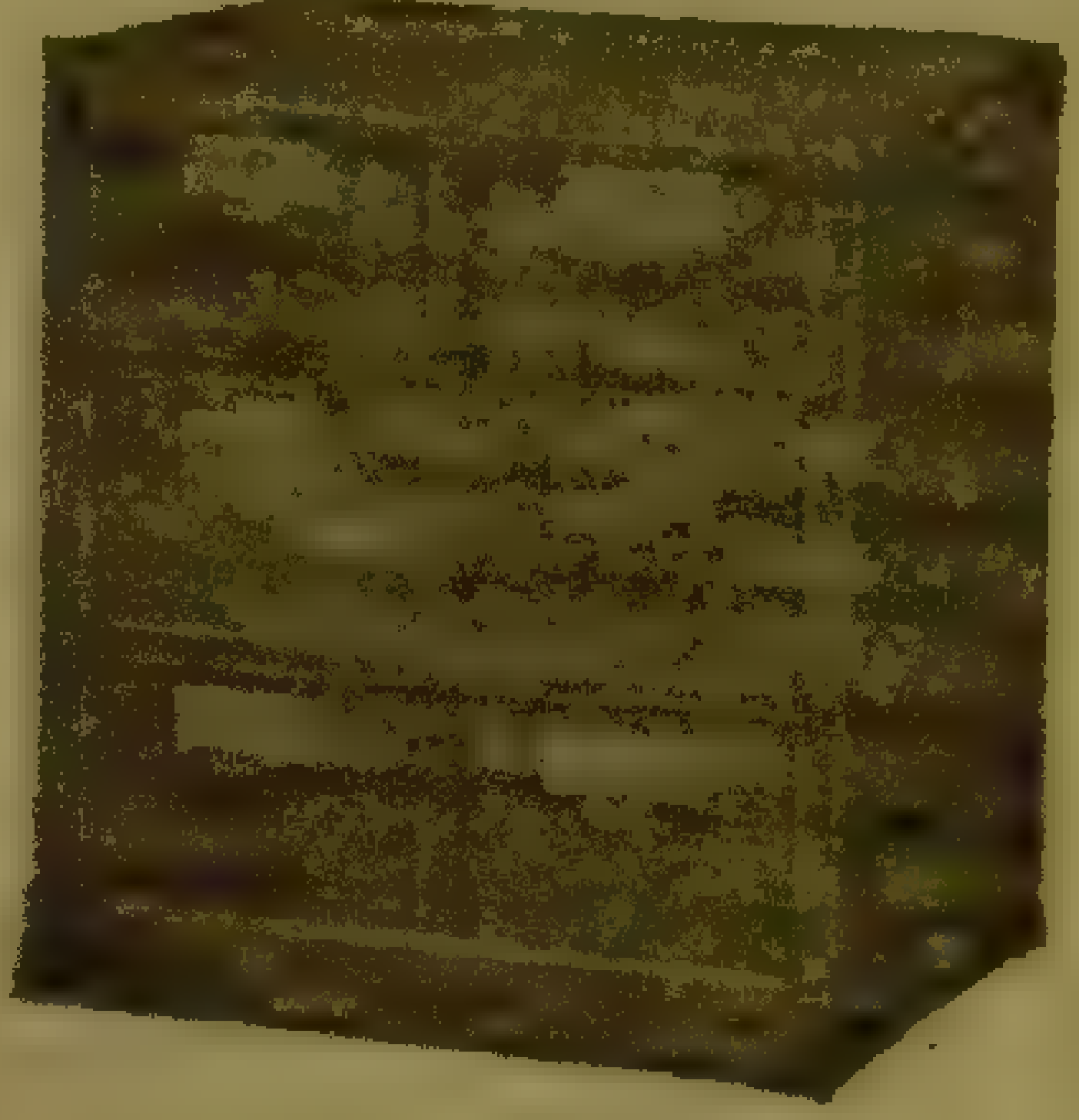

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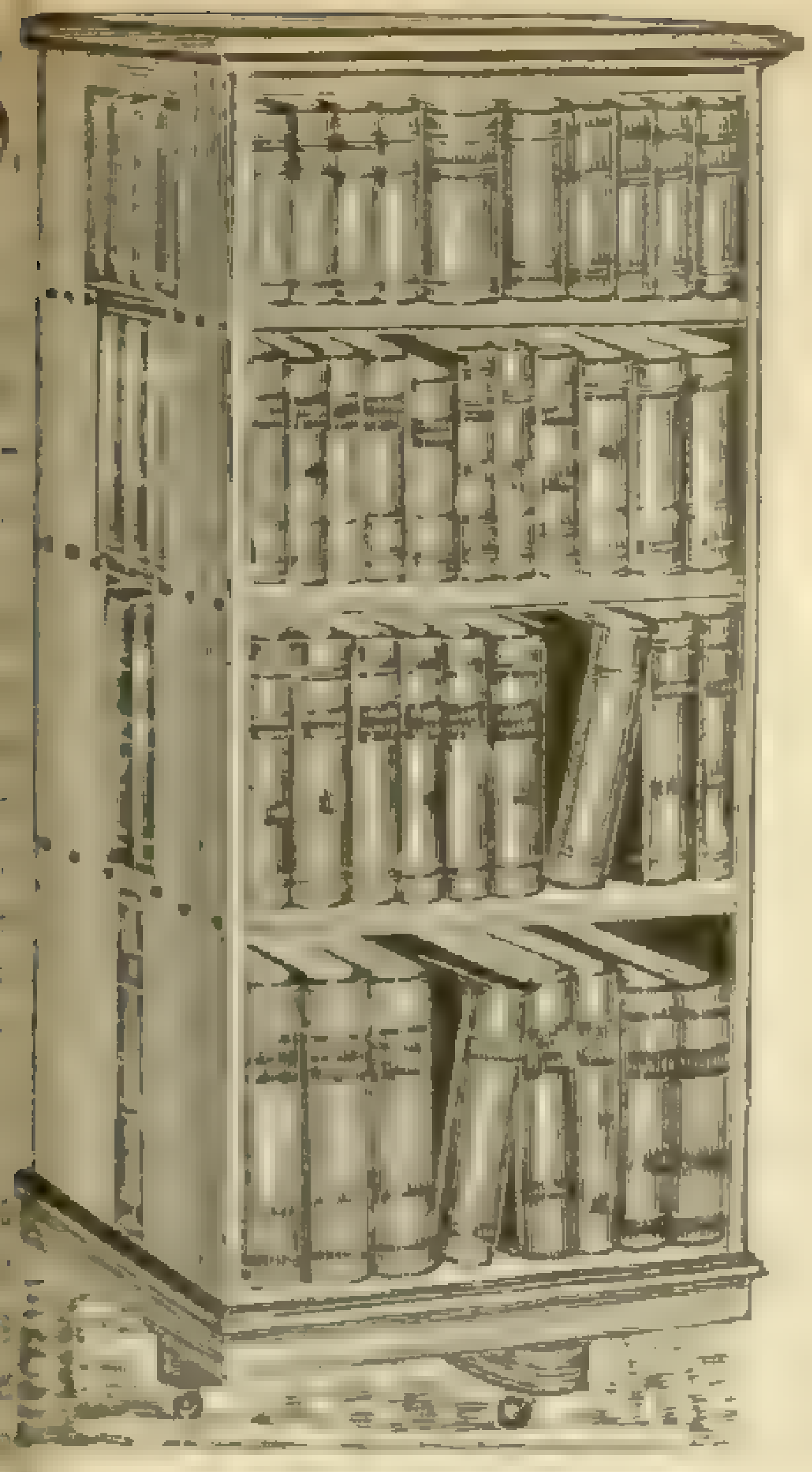

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VOLUME XXVII NUMBER 2

BOTANICAL GAZETTE

FEBRUARY 1899

NEW OR LITTLE KNOWN NORTH AMERICAN TREES

CHARLES SPRAGUE SARGENT.

IN the tenth volume of *The Silva of North America*, which was published on November 30, 1896, descriptions and figures of two species of Thrinax from southern Florida were included, and an allusion was made to the existence of two other Florida species known only from fragmentary specimens. Since the appearance of that volume I have made three journeys to the keys of southern Florida for the special purpose of studying the plants of this group, and at last I have obtained sufficient material to throw some further light on their characters and distribution.

In the original description of the genus Thrinax, founded by Swartz on a West Indian tree, the fruit is described as baccate, the size of a small pea and slightly fleshy, with a single seed, white in the interior with a red middle ("nucleus solitarius, nauco osseo fragili tectus, intus albus, medio ruber"). Martius, in 1824, in his *Palmarum Familia ejusque Genera*, practically adopted Swartz's characters for the genus, describing the albumen as "solidum, æquabile," but Endlicher, who next described Thrinax in the *Genera Plantarum*, speaks of it as "æquabile aut subruminatum," showing, probably, his acquaintance with some plant unlike the type of Swartz's genus. Martius in the *Historia Palmarum* also calls the fruit baccate, Swartz's red interior of the seed being explained by the infolding of the testa which leaves a deep basal cavity in the horny albumen. Martius, however, now enlarged the genus to include the *Thrinax argentea* of Roemer & Schultes, with seed marked by numerous vertical grooves caused by the regular infolding of the testa into the lobed albumen ("nucleus vasis impressis a basi sursum decurventibus insculptus"). Bentham & Hooker, who next described the genus, speak of the seed as vertically sulcate ("sulcis sinuatis verticalibus exculptum") without referring to the fact that in the type of the genus and in some of the species referred to it by Martius the seed is simply penetrated by a basal cavity. Drude in his study of the genus divided it into three sections, Euthrinax for the species with sulcate seeds and ruminate albumen; Heminothrinax for the younger Hooker's monotypic genus of that name with setulose perianth lobes, sessile extrorse anthers, and seeds penetrated by deep basal cavities; and Porothrinax, a name proposed (without characters) by Wendland in Grisebach's *Catalogus Plantarum Cubensium* for *Thrinax pumilio*, the type of a group of species with nearly sessile flowers, ovate acute perianth lobes, triangular filaments, and uniform albumen penetrated by a deep basal cavity—that is, with seeds similar in structure to those of Swartz's type of Thrinax. Baillon followed Drude in his treatment of the genus, and in the tenth volume of *The Silva of North America* this arrangement was also adopted. An examination of fresh material shows, however, that the fruit of the Florida species with uniform albumen penetrated by a basal cavity is drupaceous and ivory-white, and that in those species in which the seed is vertically sulcate by the infolding of the testa into the ruminate albumen the fruit is baccate and black. Principally for this reason, and for some less important characters, I propose to group the Thrinax-like plants of Florida in two genera as follows:[1]

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[1] In all the Thrinax-like plants of Florida the pericarp remains thin and crustaceous until the seed is fully developed, and then quickly thickening becomes succulent and very juicy, a character which is not often apparent in the herbarium, as the fruit is frequently collected before the pericarp begins to thicken. Even when it is gathered fully ripe the flesh becomes thin and leathery in drying and gives a very imperfect idea of the fresh fruit.

THRINAX Swartz.

Thrinax Swartz, Prodr. 57. 1788; Fl. Ind. Occ. **1**: 614. *pl. 13*.— Martius, Palm. Fam. Gen. 8; Hist. Nat. Palm. **3**: 255 (in part).— Endlicher, Gen. 357 (in part).— Drude, in Engler & Prantl Pflanzenfam. II. **3**: 34 (§ *Porothrinax*). — Sargent, Silva, **10**: 49 (§ *Porothrinax*).

Flowers solitary, minute, articulate on slender elongated or stout abbreviated disk-like pedicels in the axils of ovate acute deciduous bracts. Perianth cupular, truncate at the base, six-lobed, the lobes obscure or broadly ovate and acute, persistent under the fruit. Stamens six (or nine),[2] inserted on the base of the perianth; filaments subulate, thick and scarcely united at the base, or nearly triangular and joined below into a cup adnate to the perianth; anthers oblong, two-celled, opening longitudinally, inserted on the back below the middle, introrse, becoming reflexed and extrorse at maturity. Ovary superior, ovoid, one-celled, gradually narrowed into a stout columnar style crowned by a broadly funnelform flat or oblique stigma; ovule solitary, basilar, erect, hemi-anatropous; micropyle lateral. Fruit drupaceous, one-seeded, globose, marked at the apex with the remnants of the style and bearing at the base the slightly thickened perianth of the flower; sarcocarp thin, green, crustaceous, ultimately much thickened, ivory-white, juicy, bitter and easily separable from the thin putamen of two closely adherent coats, the outer crustaceous, pale tawny-brown and slightly tuberculate, the inner membranaceous, silvery-white and lustrous. Seed free, erect, nearly globose, slightly flattened at the two ends, depressed at the base; hilum subbasilar, oblong, pale, conspicuous; raphe short, unbranched, obscure; testa thin, pale or dark chestnut brown and lustrous; albumen uniform, more or less deeply penetrated by a broad basal cavity; embryo lateral.

Unarmed trees with simple elongated or rarely short stems marked below with the ring-like scars of fallen leaf-stalks and clothed above with the long persistent vaginas, and long tough wiry roots covered with thick orange-brown loosely attached rind. Leaves alternate, induplicate in vernation, orbicular or truncate at the base, thick and firm, usually silvery white on the lower surface, more or less divided into two-parted obliquely folded lobes with thickened margins and midribs; rachis reduced to a narrow border with a thin usually undulate reflexed margin; ligule thick, concave, pointed, often lined while young with hoary tomentum; petioles stout, elongated, flattened, slightly rounded above and below, their margins thin and smooth, concave toward the base and gradually enlarged into vaginas of coarse netted fibers covered with thick hoary tomentum. Spadix paniculate, interfoliar, pedunculate, as long as or longer than the petioles; its primary branches short, alternate, compressed, incurved, furnished with numerous slender terete alternate flower-bearing branchlets in the axils of ovate acute scarious deciduous bracts; spathes numerous, tubular, thick and firm, coriaceous, two-cleft and more or less tomentose toward the apex.

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[2] In Swartz's *Thrinax parviflora*, the type of the genus, and in all the Florida species, there are six stamens, but in *Thrinax excelsa* Grisebach, of Jamaica, the number is said to be nine, although this fact does not appear in the recent description of the species in *The Botanical Magazine* (**115**: *pl. 7088*).

To Thrinax, in addition to the three Florida species, should be referred *Thrinax parviflora* Sw., *Thrinax excelsa* Griseb., *Thrinax Morrisii* H. Wendl., *Thrinax multiflora* Mart., and *Thrinax pumilio* R. & S.

PEDICELLATAE. Flowers long-pedicellate; perianth obscurely lobed or nearly truncate; filaments subulate, hardly united at the base, much exserted; stigma oblique.

Thrinax Floridana, n. sp.

Thrinax parviflora Vasey, Rep. U. S. Dept. Agric. **1875**: 186 (*Cat. Forest Trees U. S.* (not Swartz) 1876.—Chapman, BOT. GAZETTE 3: 12. Flora S. States, Suppl. [ed. 2] 651, [ed. 3] 462.—Sargent, Silva **10**: 51 (in part), *pl. 510* as to the leaf.

Flowers on slender pedicels nearly an eighth of an inch long, ivory-white, very fragrant with a pungent aromatic odor. Fruit from one quarter to three eighths of an inch in diameter, somewhat depressed above and below. Seed from an eighth to nearly a quarter of an inch in diameter, dark chestnut-brown and lustrous, penetrated nearly to the apex by the broad basal cavity.

A tree with a slightly tapering stem from twenty to thirty feet in height and from four to six inches in diameter, covered with smooth pale blue-gray rind and generally clothed to the middle and occasionally to the ground with the persistent clasping bases of the leaf-stalks. Leaves nearly orbicular, or truncate at the base, rather longer than they are broad, yellow-green and lustrous on the upper surface, silvery-white on the lower surface, divided to below the middle into numerous lobes varying from an inch to an inch and a half in width near the middle of the leaf; ligule long-pointed, bright orange color, three quarters of an inch long and broad; petioles from four feet to four feet and a half in length, pale yellow-green, three quarters of an inch wide at the orange-colored more or less tomentose apex, much thickened and tomentose and from two inches to two inches and a half wide at the base. Spadix from three feet to three feet six inches in length, its primary branches from six to eight inches long, ivory-white when the flowers open like the slender secondary branches, but turning light yellow-green before the fruit ripens and orange-brown in drying. Flowers in June and sometimes also irregularly in October or November; fruit ripening six months later.

Dry coral ridges and sandy shores from Cape Romano to Cape Sable on the mainland and from Torch Key to Long Key. Discovered by Dr. A. W. Chapman on Cape Romano in the autumn of 1875, and on Cape Sable by Dr. A. P. Garber in October 1879. This is the *Thrinax excelsa* of Florida nurserymen but not of Grisebach. Closely related probably to *Thrinax parviflora* of Swartz, which appears to be widely distributed through the West Indies and to occur on the shore of Central America, but distinct from that species, as collected by Charles Wright in Cuba (*no. 2329*) and determined by H. Wendland, in its longer and stouter fruiting pedicels, smaller fruit and deeper seminal cavity, and pronounced unlike any of the species of

Thrinax in the Herbarium of the Royal Gardens at Kew, where, through the courtesy of the director, Mr. W. T. Thiselton Dyer, my Florida material has been compared.

Seeds of *Thrinax Floridana* were distributed from the Arnold Arboretum in December 1898, as *Thrinax species no. 2.*

SESSILIFLORÆ. Flowers short-pedicellate; perianth lobes broadly ovate, acute; filaments nearly triangular, united below into a cup adnate to the perianth; stigma flat.

Thrinax Keyensis, n. sp.—Flowers on low disk-like pedicels, ivory-white, faintly aromatic. Fruit from one sixteenth to nearly one quarter of an inch in diameter, with thin flesh. Seed three sixteenths of an inch in diameter, pale chestnut-brown, penetrated only to the middle by the basal cavity.

A tree with an ashy-gray stem often twenty-five feet in height and from ten to fourteen inches in diameter, raised on a base of thick matted roots two or three feet high and eighteen or twenty inches wide. Leaves nearly orbicular or truncate at the base but rather longer than broad, from three to four feet in length, divided for two thirds of their length into lobes which are often two and a half inches wide near the middle of the leaf, the lowest lobes parallel with the petiole or spreading from it at right angles, thick and firm, light yellow-green and very lustrous on the upper surface, with bright orange-colored midribs and much thickened orange-colored margins to the lobes, on the lower surface at first coated with hoary deciduous tomentum and at maturity pale blue-green and more or less covered with loosely attached silvery-white pubescence; ligule thick, pointed, an inch long and wide, lined at first with hoary tomentum; petioles stout, flattened above, obscurely ridged on the lower surface, tomentose while young, pale blue-green, from three to four feet long, an inch wide at the apex, and from three to four inches wide at the much thickened concave base, coated like the broad vaginas of coarse tough fibers with felt-like tomentum. Spadix six feet long, stout, spreading, gracefully incurved, its primary branches much compressed, from three to four inches in length at the base of the panicle to an inch and a half in length at the apex, bright orange colored like the short secondary branches. Flowers opening in June and occasionally also irregularly in November; the fruit ripening six months later.

Thrinax Keyensis inhabits the north shore of the largest of the Marquesas group of islands about fifteen miles west of Key West, where it was first seen by me in November 1886, but without flowers or fruit, and where there are several large groves; it grows also on Crab Key, a small island to the westward of Torch Key, one of the Bahia Honda group. It is this plant which I referred to EUTHRINAX (Garden and Forest **9**: 162; Silva **10**: 50), with the mistaken idea that the large black fruit which I had gathered on the Marquesas in 1886 had been produced by this tree. Seeds of *Thrinax Keyensis* were distributed from the Arnold Arboretum in December 1898 as *Thrinax no. 3*.

THRINAX MICROCARPA Sargent, Garden and Forest **9**: 162. 1896; Silva **10**: 53. *pl. 511.*

This tree, which is the commonest and most generally distributed species on the south Florida keys, is correctly figured in the tenth volume of *The Silva*, except the fruit, which, until recently, I supposed to have an orange-brown crustaceous pericarp. It differs from *Thrinax Keyensis* in its taller and more slender trunk without a basal enlargement, in its shorter spadix and smaller fruit with darker colored seeds, and in its smaller and thinner leaves. The structure of the flower and fruit is identical. This is the *Thrinax argentea* of Curtiss's distribution (*no. 2679*), but not of Loddiges, which belongs to another genus.

COCCOTHRINAX, n. gen. CORYPHEÆ.

Thrinax Endlicher, Gen. 253. 1836 (in part). Martius, Nat. Hist. Palm. **3**:254 (in part). Bentham & Hooker, Gen. **3**:930. Drude in Engler & Prantl Pflanzenfam. II. **3**:34 (§ EUTHRINAX). Baillon, Hist. Pl. **13**:317 (in part). Sargent, Silva **10**:49 (§ EUTHRINAX.)

Flowers perfect, solitary, minute, articulate on slender pedicels in the axils of ovate acute caducous bracts. Perianth cupular, truncate at the base, obscurely six-lobed, deciduous. Stamens nine, inserted on the base of the perianth, exserted; filaments subulate, barely united at the base; anthers oblong, attached on the back near the middle, introrse, two-celled, the cells opening longitudinally. Ovary superior, ovoid, one-celled, narrowed above into a slender columnar style crowned by the funnelform oblique stigma; ovule solitary, basilar, anatropous; micropyle subbasilar. Fruit baccate, subglobose, one-seeded, crowned with the remnants of the style, raised on the thickened torus of the flower; exocarp at first thin, of two closely united coats, the outer crustaceous, bright green, the inner membranaceous, silvery-white; in ripening becoming thick, sweet, juicy, homogeneous, black and lustrous, easily separable from the seed. Seed free, erect, depressed-globose; testa thick and hard, vertically sulcate with numerous narrow grooves running irregularly from the base of the seed toward its apex, deeply infolded into the ruminate albumen; hilum subbasilar, minute, obscure; raphe hidden in the folds of the testa; embryo lateral.

Trees with slender stems marked below by the ring-like scars of fallen leaf-stalks and clothed above with the long-persistent petiole-sheaths, or rarely stemless. Leaves terminal, induplicate in vernation, alternate, orbicular or truncate at the base, pale or silvery-white on the lower surface, thin and brittle, more or less deeply divided into narrow acute two-parted obliquely folded lobes; rachis short; ligule free, thin, erect, concave, rounded or long, pointed at the apex; petioles compressed, slightly rounded and ridged on the two surfaces, thin and smooth on the margins, gradually enlarged below into elongated vaginas of coarse fibers forming an open conspicuous net work generally clothed while young with thick hoary tomentum. Spadix interfoliar, paniculate, shorter than the petioles; its short primary branches incurved, furnished with numerous short flower-bearing secondary branchlets from the axils of scarious acute bracts; spathes numerous, papyraceous, two-cleft at the apex.

The generic name is in allusion to the berry-like fruit.

The following extra-Florida species previously referred to

Thrinax belong in Coccothrinax. *Thrinax argentea* R. & S.; *Thrinax radiata* R. & S. (*Thrinax gracilis*, *elegans* and *aurita* of gardens). Wright's *no. 3966* from Cuba labeled *Thrinax acuminata* Griseb. & Wendl., apparently an unpublished name, also belongs to this genus.

Coccothrinax jucunda, n. sp.

Thrinax parviflora Sargent, Forest Trees N. Am., Tenth Census U. S. 9:217. 1884 (not Swartz); Silva 10:51, in part *pl. 510* (excl. figure of leaf).

Thrinax argentea Chapman, Flora S. St. [ed. 3] 462. 1897 (not Roemer & Schultes).

Flowers raised on rigid spreading pedicels an eighth of an inch long; perianth white; anthers light yellow; ovary orange color; stigma pale rose color. Fruit from one half to three quarters of an inch in diameter, bright green when fully grown, later becoming succulent, bright violet color, very lustrous and ultimately nearly black, the flesh sweet and edible. Seed light tawny-brown, from an eighth to a quarter of an inch in diameter. Flowers in June and also irregularly in November; fruit ripening six months later.

A tree with a stem slightly enlarged from the ground upward, from fifteen to twenty-five feet in height and from four to six inches in diameter, covered with pale blue-gray rind. Leaves nearly orbicular but rather longer than broad, thin and brittle, from eighteen to twenty-four inches in diameter, divided to below the middle or toward the base of the leaf nearly to the ligule into narrow lobes, an inch across in their widest part, with much thickened bright orange-colored midribs and margins, pale yellow-green and very lustrous on the upper surface, bright silvery-white on the lower surface: rachis thin, undulate, obtusely short-pointed, dark orange colored; ligule thin, concave, crescent shaped, often oblique, slightly undulate, occasionally obtusely short-pointed, three quarters of an inch wide, one third of an inch deep, light or dark orange color; petioles slender, flexible, soon becoming pendent, rounded on the upper side, obscurely ribbed on the lower side, with low rounded ribs, from two and a half to three feet long, pale yellow-green, an inch and a half wide at the base, coated at first like the young leaves with silvery-white deciduous tomentum toward the orange colored apex. Spadix from eighteen to twenty-four inches in length with a flattened peduncle, slender, much flattened, primary branches from eight to ten inches long and light orange-colored like the slender terete secondary branches; spathes thin, fibrous, brittle, pale reddish-brown and coated toward the ends with pale pubescence.

Dry coral ridges from the shores of Bay Biscayne, where it is rare, along many of the southern keys to the Marquesas group, west of Key West. Discovered by A. H. Curtiss in 1880. Very similar to *Thrinax argentea* R. & S., the seeds differing, however, from those of that species as named in the herbarium of the Royal Gardens, Kew, in their brown, not mahogany-red, color and larger size.

Coccothrinax Garberi, nom. nov.

Thrinax Garberi Chapman, Bot. Gazette 3:12. 1878; Flora S. States Suppl. [ed. 2] 651. Sargent, Silva **10**:50.

Thrinax argentea var. *Garberi* Chapman, Flora S. States [ed. 3] 462. 1897.

A stemless plant similar to the last in the structure of its flowers and fruit and in the texture and color of the leaves, but smaller in all its parts, the leaves being only about ten or twelve inches in diameter. Found only on dry coral ridges near the shores of Bay Biscayne, and possibly only a depauperate form of the last.

Serenoa arborescens, n. sp.— Flowers minute, one twentieth of an inch long or less, perfect, sessile, in from one to three-flowered clusters in the axils of ovate acute chestnut-brown bracts, bibracteolate. Calyx truncate at the base, three-lobed, the lobes oblong, rounded and more or less laciniate on the margins, light chestnut-brown, thickened and persistent under the fruit. Corolla yellow-green, three-parted to the base, the divisions valvate in æstivation, oblong-ovate, thick, concave.

acute and much thickened at the apex, grooved on the inner surface with two or three deep depressions, deciduous. Stamens six, included; filaments nearly triangular, united below and adnate to the short tube of the corolla; anthers short-oblong, attached on the back below the middle, introrse, two-celled, the cells opening laterally. Ovary oblong-obovate, of three carpels free below, united above into a slender elongated style; stigma minute, terminal on the fruit; ovule solitary, erect from the bottom of the cell, anatropous. Fruit drupaceous, one-seeded, globose, one third of an inch in diameter, black and lustrous, usually bearing at the base the minute abortive carpels; exocarp thin and fleshy; mesocarp thin, fibrous, orange colored, strong-smelling, closely investing the pale brown crustaceous putamen. Seed free, subglobose, somewhat flattened below; testa hard, chestnut-brown and lustrous, lighter-colored on the ventral side with a large pale circular mark; hilum basal; raphe ventral, oblong, acute, unbranched; micropyle joined to the testa by a pale band; albumen homogenous; embryo lateral.

A tree thirty or forty feet in height with one or several stems three or four inches in diameter, clothed above for many years with the vaginas of the leaf stalks and covered below with smooth pale gray bark, and erect or often more or less inclining and occasionally semiprostrate. The leaves are terminal, semiorbicular, truncate at the base, thin and firm, bright yellow-green on the upper surface, blue-green on the lower surface, two feet wide and long, divided nearly to the base into narrow linear-lanceolate lobes, their midribs and margins only slightly thickened and pale yellow; rachis acute, its narrow border free, thin and membranaceous; ligule thin, concave, short-pointed, furnished with a deciduous membranaceous red-brown border a quarter of an inch wide; petioles slender, flat on the upper surface, convex and stoutly ribbed on the lower surface, from eighteen to twenty-four inches long, one third of an inch wide at the apex, an inch wide at the base, armed with stout flattened orange-colored teeth; vaginas thin and firm, bright mahogany-red, very lustrous, closely infolding the stem, their fibers thin and brittle. The spadix is interfoliar, from three to four feet long, its stem slender and flattened; branches slender, elongated, paniculate, gracefully drooping, coated with hoary tomentum, the ultimate divisions terete; bracts ovate, acute, chestnut-brown; spathes six or eight, sheathing the peduncle, thick and firm, deeply two-cleft at the apex furnished with a narrow membranaceous red-brown border.

Margins of swamps adjacent to the Chockoloskee river in southwestern Florida.

This second species of Serenoa differs from the type of the genus, the well-known saw palmetto of the southern states, in its arborescent habit, more elongated spadix, much smaller flowers, and smaller globose fruit and seeds, and is certainly a most interesting addition to the trees of the United States. The existence of an undescribed arborescent palm on the Chockoloskee river was known to me as long ago as 1887, when it was discovered without flowers and fruit in the Royal Palm Hummock, not far from the town of Everglade, by the late P. W. Reasoner, of Oneco, Florida; but it was not until the past season that I obtained the flowers and fruit from Mr. R. G. Corbitt, of Immockalee, Florida, who has found this palm growing abundantly in the swamps about thirty miles southeast of Lake Trafford, near the head of the Chockoloskee. In December 1898, seeds of *Serenoa arborescens* were distributed from the Arnold Arboretum as "New palm from the Florida everglades."

Ulmus (Microptelea) **serotina,** n. sp.—Arborescent. Leaves oblong to oblong-obovate, acuminate, variously oblique at the base, coarsely and doubly crenulate-serrate, membranaceous, glabrous and lustrous above, puberulous below on the prominent midribs and veins. Flowers perfect, autumnal, racemose, from buds in the axils of leaves of the year, long-pedicellate. Calyx six-parted to the base, its divisions oblong-obovate, rounded at the apex. Ovary sessile, narrowed below, hirsute. Samaras stipitate, oblong-elliptical, deeply two-parted at the apex, ciliate on the margins. Seeds obovate; raphe conspicuous. Young leaves, stipules and bracts unknown.

A tree with a trunk forty or fifty feet in height and from two to three feet in diameter covered with close pale gray bark, comparatively small spreading or pendulous branches, slender pendulous branchlets, light reddish-brown, lustrous and marked occasionally with white lenticels, growing darker during their second season, ultimately dark gray-brown and often furnished in their second or third year with two or three thick corky wings. The winter-buds are ovate, acute, a quarter of an inch in length and covered with numerous oblong-obovate dark chestnut-brown scales. The leaves are thin and firm in texture, yellow-green and lustrous on the upper surface, rather paler on the lower surface, from two to three inches in length, with prominent midribs and about twenty pairs of primary veins running to the points of the principal teeth and often forked near the margin of the leaf, obscure reticulate veinlets, and stout petioles a quarter of an inch in length; in the autumn they turn orange-yellow before falling. The flowers are reddish-brown with yellow anthers, and are borne on slender conspicuously jointed pedicels often an eighth of an inch long in many-flowered racemes from an inch to an inch and a half in length. The fruit, which ripens early in November, is about half an inch long and is fringed on the margins with long silvery-white hairs.

Banks of the French Broad river near Dandridge, Tennessee; limestone bluffs of the Cumberland river, near Nashville, Tennessee; limestone ridges near Huntsville, Alabama, and Rome, Georgia; occasionally planted as a shade tree in the streets of Huntsville and Rome, and when cultivated in good soil and with abundant space distinguished by its broad handsome head of pendulous branches.

Ulmus serotina was collected by Rugel on the French Broad river in October 1842[3]; it was found near Nashville, by Dr. A. Gattinger, as early, at least, as 1879, and, although he noticed its autumnal flowers, it was referred by him to *Ulmus racemosa*. It has been distributed without flowers or fruit as *Ulmus racemosa* from the Biltmore Herbarium (*no. 3634 b*) from collections made at Nashville in 1897; and on the 9th of October, 1898, a single large tree in fruit was seen by Mr. John Muir, Mr. William M. Canby, and myself close to the high road which leads eastward from Huntsville across the ridge known as Monte Sano. Subsequently it was found to be abundant on the hills near Huntsville and on those in the neighborhood of Rome by Mr. C. L. Boynton, of the Biltmore Herbarium. It is the *Ulmus racemosa* of Chapman's *Flora* (ed. 2, Supplement, 649; ed. 3, 444) so far as relates to the river banks of Tennessee, and the *Ulmus racemosa* of Sargent's *Silva* (**7**: 48) so far as relates to middle Tennessee.

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[3] One of Rugel's specimens, with a few fragmentary flowers, is preserved in the herbarium of Columbia University.

Ulmus serotina is an interesting addition to the small group of autumn-flowering elms in which the calyx is divided to below the middle (MICROPTELEA of Spach), and to which belong *Ulmus crassifolia* Nutt. of southern Arkansas and Texas, and *Ulmus parvifolia* Jacq. of northern and central China. From these it differs in its racemose flowers, more deeply divided calyx with obovate lobes, and in its much larger and acuminate leaves. The Himalayan *Ulmus lancifolia* Roxb. (*Ulmus Hookeriana* Planchon), also with a deeply divided calyx, is placed by Planchon (De Candolle, Prodr. **17**: 162) in MICROPTELEA, but the flowers, which are borne in short racemes, appear in spring from the axils of leaves of a previous year.

ARNOLD ARBORETUM.

THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

PART I.—GEOGRAPHICAL RELATIONS OF THE DUNE FLORAS.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XIII.

HENRY CHANDLER COWLES.

(WITH FIGURES 1–26)

I. Introduction.

THE province of ecology is to consider the mutual relations between plants and their environment. Such a study is to structural botany what dynamical geology is to structural geology. Just as modern geologists interpret the structure of the rocks by seeking to find how and under what conditions similar rocks are formed today, so ecologists seek to study those plant structures which are changing at the present time, and thus to throw light on the origin of plant structures themselves.

Again, ecology is comparable to physiography. The surface of the earth is composed of a myriad of topographic forms, not at all distinct, but passing into one another by a series of almost perfect gradations; the physiographer studies landscapes in their making, and writes on the origin and relationships of topographic forms. The ecologist employs the methods of physiography, regarding the flora of a pond or swamp or hillside not as a changeless landscape feature, but rather as a panorama, never twice alike. The ecologist, then, must study the order of succession of the plant societies in the development of a region, and he must endeavor to discover the laws which govern the panoramic changes. Ecology, therefore, is a study in dynamics. For its most ready application, plants should be found whose tissues and organs are actually changing at the present time in response to varying conditions. Plant formations should be found which are rapidly passing into other types by reason of a changing environment.

These requirements are met *par excellence* in a region of sand dunes. Perhaps no topographic form is more unstable than a dune. Because of this instability plant societies, plant organs, and plant tissues are obliged to adapt themselves to a new mode of life within years rather than centuries, the penalty for lack of adaptation being certain death. The sand dunes furnish a favorable region for the pursuit of ecological investigations because of the comparative absence of the perplexing problems arising from previous vegetation. Any plant society is the joint product of present and past environmental conditions, and perhaps the latter are much more potent than most ecologists have thought. As will be shown in another place, even the sand dune floras are often highly modified by preexisting conditions, but on the whole the physical forces of the present shape the floras as we find them. The advancing dune buries the old plant societies of a region, and with their death there pass away the influences which contributed so largely to their making. In place of the rich soil which had been accumulating by centuries of plant and animal decay, and in place of the complex reciprocal relations between the plants, as worked out by a struggle of centuries, the advance of a dune makes all things new. By burying the past, the dune offers to plant life a world for conquest, subject almost entirely to existing physical conditions. The primary motive, then, which prompted this present study was the feeling that nowhere else could many of the living problems of ecology be solved more clearly; that nowhere else could ecological principles be subjected to a more rigid test.

This particular investigation was also prompted by the fact that the previous ecological studies of sand-dune floras have been carried on chiefly in European countries, and almost exclusively along marine coasts. There has been considerable difference of opinion as to the influence of salty soils and atmospheres upon the vegetation. It would seem that a comparison of dunes along an inland fresh water lake with those along the sea should yield instructive results.

An ecological study of this character has a natural twofold division. In the first place the plant formations are to be investigated. The species characteristic of each formation must be discovered, together with the facts and laws of their distribution. The progressive changes that take place and the factors in the environment which cause these changes must be discussed. This phase of the subject is largely geographic, and will be the special feature of the present paper. In another paper it is the author's purpose to discuss the adaptations of the plants to their dune environment, paying especial attention to those species which show a large degree of plasticity, and which are found growing under widely divergent conditions. This second phase again has a natural twofold division, one part treating of gross adaptations such as are shown in plant organs and plant bodies, the other dealing with the anatomical structures of the plant tissues.

The material for the present paper has been gathered chiefly from the study of the dunes in northwestern Indiana in the vicinity of Chicago. These studies were carried on in the seasons of 1896, 1897, and 1898, frequent visits being made to various points at all seasons of the year. A portion of the summer seasons of 1897 and 1898 was spent in a more rapid reconnoissance along the entire eastern shore of Lake Michigan, including the group of islands toward the north end of the lake.

The work resulting in this paper has been carried on in connection with the Hull Botanical Laboratory of the University of Chicago, and the author gratefully acknowledges the kindly interest and cooperation shown by his associates among the faculty and students of the botanical department, especially Head Professor John M. Coulter, through whose influence the author was directed along lines of ecological research. The author further desires to express his great indebtedness to Dr. Eugen Warming, professor of botany at Copenhagen; his text-book on ecology and his treatises on the sand-dune floras of

Denmark have helped greatly to make clear the true content of ecology, and they have been a constant incentive to more careful and thorough work. Most of the photographs were taken especially for this paper by Mr. E. W. Martyn, a Chicago photographer. Some of the views were taken by Messrs. S. M. Coulter and H. F. Roberts, students in the Hull Botanical Laboratory. The map was prepared by Mr. S. M. Coulter.

II. General features of the coast of Lake Michigan.

Along the eastern shore of Lake Michigan there are hills of wind-blown sand almost continuously fringing the border of the lake. This line of sand hills also continues around the southern end of the lake and along the western shore as far as Chicago. These sand hills or sand dunes form striking topographic features in the landscape, and in this respect present a strong contrast to the level prairies or fields beyond.

Geologically speaking, the sand dunes belong to the most recent formations, as they are entirely post-glacial. In most cases the origin of the existing topographic forms is to be referred to the most recent phases of post-glacial history, and in many instances the topographic forms are either being made or unmade at the present time. As a rule the dunes are directly superposed upon the beach. On the northeastern shores of the lake, however, the dunes are commonly superposed upon bluffs of clay or gravel, sometimes 120 meters above the present beach.

In the lake region there is a decided prevalence of westerly winds, chiefly from the southwest or northwest. As a consequence, the dunes are found along the entire eastern and southern shores of the lake, whereas the dunes on the western shore, due to easterly winds are merely small hillocks of sand. Such small dunes have been seen at Waukegan, Ill., and on North Manitou and Beaver islands. The dunes toward the southern portion of the lake were created and fashioned, as a matter of necessity almost entirely by the northwest winds. In order to secure any extensive formation of sand dunes, it is necessary for the wind to gather force by sweeping over the lake and to strike the coast

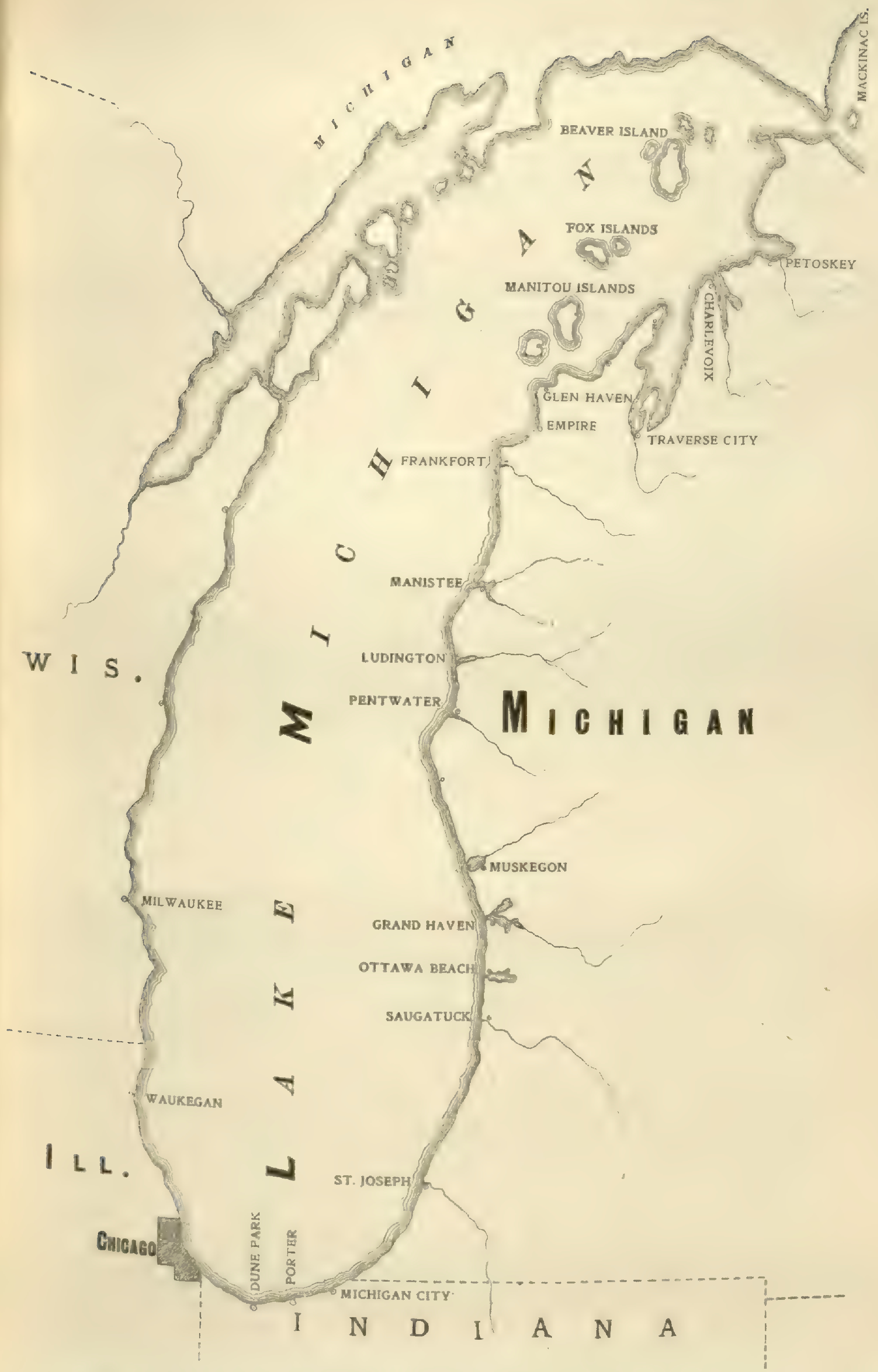
MICHIGAN
MACKINAC IS.
BEAVER ISLAND
FOX ISLANDS
PETOSKEY
MANITOU ISLANDS
CHARLEVOIX
GLEN HAVEN
EMPIRE
TRAVERSE CITY
FRANKFORT
MANISTEE
WIS.
LUDINGTON
PENTWATER
MICHIGAN
LAKE MICHIGAN
MUSKEGON
MILWAUKEE
GRAND HAVEN
OTTAWA BEACH
SAUGATUCK
WAUKEGAN
ILL.
ST. JOSEPH
CHICAGO
DUNE PARK
PORTER
MICHIGAN CITY
INDIANA

FIG. 1.—MAP OF THE SHORE OF LAKE MICHIGAN. SCALE, 1:2,850,000.

almost at right angles to the shore line. It will thus be seen that the most favorable theoretical locality for dunes in a region of northwest winds is on the southeast shore of a body of water in that region. As a matter of fact, the dune region increases in area and the dunes themselves increase in height and complexity as one passes from Chicago around the south end of Lake Michigan. The culmination of the dune formations actually occurs between Dune Park and Michigan City, and an examination of the accompanying map (*fig. 1*) will show that these localities have a shore line running nearly southwest to northeast. The contour of the dunes themselves also shows that they were shaped by northwest winds, as does the path formed by the sweeping of the wind.

The Dune Park region furnishes the most extensive area of present dune activity to be found along the southern coast of Lake Michigan, although the altitudes of individual dunes are much greater at many points in Michigan. Elsewhere the active dunes are usually confined to a very narrow belt fringing the shore, but at Dune Park the dunes are active from one to two kilometers inland, the front of the advancing dunes varying from 6 to 30 meters in height. The dune complex or area of dune activity at Dune Park covers perhaps 1000 hectares. The established dunes here as elsewhere cover a far greater area than do the active dunes, reaching inland three to eight kilometers. Between Chicago and Dune Park there is a most interesting series of parallel ridges, alternating with depressions which often reach below the water level throughout the entire year. The origin of these ridges is scarcely within the province of this paper; their extreme regularity of contour, in addition to their persistent parallelism, seems hardly consonant with a dune origin. Because of the low altitude of these ridges and their protection from shore conditions, their flora is not typically xerophytic. Whatever the origin of these ridges, they represent a phase in the lake's history when its waters were much farther inland than at present. The active dunes at Dune Park are scarcely ever more than 30 meters in altitude, but there are several established dunes which are more than 36 meters above the lake. The coast charts issued by the Corps of Engineers of the United States War Department figure a dune near Porter, Ind., which reaches an altitude of 57 meters above the lake. Of course, altitudes of individual dunes are subject to much change, although in the case of established dunes the figures need but slight revision. The highest series of dunes is along the Michigan shore between Michigan City and St. Joseph. A large number of dunes reach an altitude of more than 60 meters; several are over 90 meters high; and one is figured on the coast chart which has an altitude of 117 meters above the level of the lake. An inspection of the map will show that these dunes must have been shaped primarily by northwest winds.

The Michigan shore between St. Joseph and Frankfort, a distance of more than 250 kilometers, is fringed almost continuously with a narrow belt of dunes. Perhaps at no place within this region are there such extensive dunes in activity at the present time as at Dune Park, nor do the established dunes reach inland as a rule for more than a kilometer. At Dune Park there is a gradation in the altitude of the dunes as one goes inland, until the low sand ridges pass all but insensibly into the prairies beyond. Along the Michigan shore, however, there is a narrow fringe of dunes close to the lake, commonly much higher than at Dune Park, and the transition between these dunes and the normal inland country is rapidly passed and plainly marked.

A very striking feature along the Michigan shore is the tendency of rivers to form small lakes near their mouths. These lakes determine the presence of cities, since they furnish the best of harbors. An inspection of the map (*fig. 1*) shows the presence of such natural harbors at the mouths of rivers at Holland (Ottawa Beach), Grand Haven, Muskegon, Whitehall, Pentwater, Ludington, and Manistee. A large amount of the silt brought down by the rivers is deposited at the mouth, where the river currents are slackened by their opening out into the lake and by wave action. The waves pile up this sand along the beach and the winds pick it up and form extensive dunes at the river's mouth. All along the Michigan coast the most extensive areas of active dunes are likely to be at the mouths of the rivers, so that dune formation is thus seen to be regulated by the supply of sand as well as by the relation of the coast line to the direction of the prevailing winds. Since the general direction of the Michigan coast line is north and south, and the prevailing winds southwest and northwest, dune formation tends to close up the mouths of the rivers on both sides. The result of this conflict between the river and air currents is seen in the formation of lakes whose entrance into Lake Michigan is constricted into a narrow passageway. The tendency of the wind to close these passageways is so great that navigation is often difficult, and the necessity for constant dredging and erection of wind-breaks is obvious.

The dunes at the mouths of rivers furnish a rough measure for determining the relative influence of northwest and southwest winds in dune formation, since those on the south side are largely shaped by southwest winds and those on the north side by northwest winds, although each wind modifies the action of the other. At Saugatuck the southwest winds appear to dominate, since the dune south of the river is 78 meters high while to the north the heights are inconspicuous. The course of the Kalamazoo river has been deflected to the northward at this point, although it is interesting to observe that the mouth is now being deflected to the southward, the river filling in on the northwest bank and eroding on the southeast. At Ottawa Beach the dunes are about equal on both sides, and less than 60 meters in height. At Grand Haven there is an immense active dune on the north side of the river, 66 meters high, and with an advancing lee slope 45 meters in height. This dune is deflecting the river to the southward, and attempts to stop its progress are not particularly successful. The dunes at Muskegon are largest on the south side of the river. At Pentwater, Ludington and Manistee the dunes average about 45 meters in height. The fringe of dunes is interrupted at several points by clay bluffs but this latter formation is far more extensive farther northward

Active dune formation is conspicuous on projecting points of land as well as at the mouths of rivers; for example, active dunes are to be found on Little Point Sable, south of Pentwater, and Big Point Sable, north of Ludington. At many points along the coast the winds are breaking through the fringe of established dunes, so that the older dunes may be said to have started into activity again or to have become rejuvenated. In summation concerning the area between St. Joseph and Frankfort, it may be said that the influence of northwest and southwest winds in dune formation is nearly equal. Indeed, the two winds commonly work together to produce a composite result, so that the winds sweep and the dunes advance, as a rule, from west to east.

In northern Michigan, between Frankfort and Glen Haven, and also on North Manitou island, most of the dunes are perched high up on bluffs of clay or gravel. The bluffs are steep and approach the water's edge, varying in height from nothing up to more than 120 meters. Dunes are to be found upon the tops of the very highest of these bluffs in the district south of Glen Haven. These perched dunes are almost wholly established, and it seems as if their formation took place years ago when the lake was perhaps at a higher level. The most remarkable dune formation along the entire coast of Lake Michigan is to be found on Sleeping Bear point, just south of Glen Haven. The point stretches out into the lake, and is constantly growing to the northward and eastward by reason of the joint action of waves and winds. The point proper is geologically quite young, and, apart from the present beach and stationary beach dunes, is covered by an immense and active dune complex. At many points the wind has scooped out great hollows in the complex, exposing the gravel of a former beach. The advance of the dunes in this area is chiefly eastward, the exposed fossil beaches being chiefly toward the west. Two or three kilometers southward from the point, the region of low active dunes passes somewhat suddenly into an immense flat-topped hill, rising abruptly from the lake like a mesa or terrace. The height of the dunes on the point is seldom greater than 30 to 45 meters, while this peculiar gravel terrace, or mesa, has an average height of 120 meters above the lake level, and an area of more than 2000 hectares, since it extends inland for about two kilometers, and along the coast for, perhaps, 15 kilometers. The Sleeping Bear itself, which gives its name to the point, and also to the bay, is a long established dune, with an altitude of 30 meters above the terrace on which it stands, or 150 meters above the lake. This dune stands alone, and is a landmark for miles in all directions. Farther to the south, dunes are perched upon these bluffs almost continuously, and there are reasons for supposing that the Sleeping Bear is but the last remnant of such a chain of dunes formerly superposed on the bluffs near Glen Haven. Toward the east and north, as well as toward the lake, the slopes of the mesa-like formation are quite abrupt, and beyond these slopes there is to be found an extensive dune complex, the grandest in variety and beauty to be found along Lake Michigan. It seems almost certain that the source of the sand for this dune complex was an ancient row of dunes at the top of the mesa toward the west. This is made more probable by the fact that the Sleeping Bear, once firmly established, is now being torn up by the winds and carried northeastward. The dune complex is moving toward the east, the line of advance being parallel to the lake shore, as usual. This advancing dune is far and away the grandest along Lake Michigan, presenting an almost continuous front, measuring four kilometers from north to south, all in active progression. The average height above the country on which it is encroaching is about 60 meters, so that it presents a most imposing sight when viewed from the fields in front of its line of advance. The dune complex at Glen Haven is like that at Dune Park, but on a far grander scale; sometimes there are hollows within it more than 30 meters in depth scooped out by the wind, and reaching down to an ancient beach. Within the dune complex there are extensive old soil lines and many scarred trunks of trees, long buried by the dunes and now resurrected, though not to life.

At many other places along the northern shore of the lake there are high bluffs of clay, or gravel, whose summits are crowned by established dunes. Only rarely are these dunes in action at the present time, and, where such action is observed, it is clearly due to the rejuvenation of dunes that had become established. The origin of these perched dunes is obscure and hardly within the province of this paper. The formation of dunes at the summit of a bluff is not unknown. A wind laden with sand may sweep up the slopes of a hill. As it reaches the summit its path is no longer narrowly restricted, and as it spreads out, its energy is dissipated and its load deposited. However, no such action was anywhere observed; on the contrary, at many points the wind is removing the dunes from just such locations. Consequently the author rather inclines to the belief that these perched dunes represent an earlier phase of dune formation, when lake or wind conditions were different from the present. Another possible mode of origin will be discussed in connection with the rejuvenated dunes.

The greatest altitude reached by the clay and gravel bluffs is at Empire, a few miles south of Glen Haven; at this point a height of 128 meters is attained. There is a high degree of oscillation in the altitudes even within a few meters. Where the clay bluffs are highest, the perched dunes are seldom as high as where the bluffs are lower. The greatest observed height of the perched dunes above the top of the clay was 60 meters. The greatest total observed height above the lake at Empire was 162 meters; at Frankfort 153 meters. South of Frankfort and north of Glen Haven the altitudes are much less. At Charlevoix and Petoskey there are no cliffs; the dunes are low and superposed directly upon the beach.

The islands in the north end of the lake are of great interest to the student of dunes, since they are exposed to winds from all directions; the position of the dunes thus indicates the direction of the dune-forming winds. In all cases the chief dune formation is on the west coast, and the most conspicuous active dunes are usually restricted to a narrow area at or near the southwest point of each island. Observation from the steamboat revealed the presence of such dunes on South Manitou, South

Fox, and High islands. The dunes on North Manitou and Beaver islands were visited. On North Manitou there are prominent areas of dune activity along the southwest coast, the dunes being superposed on bluffs of clay or gravel. There is a flat-topped terrace here, like that at Glen Haven, but in miniature, the height being only 15 meters and the area scarcely half a hectare; the dune perched on this bluff has been rejuvenated and carried inland a few meters, the greatest altitude being 45 meters above the lake. There are also small wandering dunes superposed directly upon the beach. On the west coast the bluffs are steeper and much higher, at times perhaps 60 meters above the lake; the summits are occasionally crowned by established dunes. On Beaver island the southwest coast was not visited, but there are rejuvenated dunes at various points along the west coast, sometimes 45 meters in height; these dunes are superposed upon the beach. The beach dunes here are exceedingly varied and extensive. As previously stated, there are low beach dunes along the east coast of Beaver island. On Mackinac island there are steep clay bluffs, but no dunes. Thus, the islands plainly show that westerly winds, and especially winds from the southwest, are the chief dune formers.

Surveying the lake region as a whole, the dunes are created and shaped almost entirely by westerly winds. In the southern portions of the lake, the northwest winds have the greater sweep and are the chief dune-formers. Northward the southwest winds are the chief factors in determining the location of dunes. In intermediate localities all westerly winds contribute about equally to dune formation, and there is progressive movement of active dunes to the eastward

III. The ecological factors.

The distribution of the plants in the various dune associations is governed by physical and biotic agencies which will be considered somewhat in detail in another place. At this point it seems advisable to give a general survey of these factors, especially in so far as they affect the distribution of plant societies of the region as a whole.

LIGHT AND HEAT.

Nearly all of the dune societies are characterized by a high degree of exposure to *light*. Particularly is this true of the beach and the active dunes. The intensity of direct illumination is greatly increased by reflection; the glare of the white sand is almost intolerable on a bright summer day. The *temperature* relation is even more marked in its influence upon plant life. Because of the absence of vegetation and the general exposure of sand dunes the temperature is higher in summer and lower in winter than in most localities. This great divergence between the temperature extremes is still further increased by the low specific heat of sand. On sandy slopes protected from cold winds the vegetation renews its activity very early in the spring, because of the strong sunlight and the ease with which the surface layers of sand are heated. Willow shoots half-buried in the sand frequently develop fully a week in advance of similar shoots a few centimeters above the surface. Similarly in the autumn the activity of plant life ceases early largely because of the rapid cooling of the superficial layers of sand, as well as because of direct exposure to the cold.

WIND.

The wind is one of the most potent of all factors in determining the character of the dune vegetation. The winds constantly gather force as they sweep across the lake, and when they reach the shore quantities of sand are frequently picked up and carried on. The force with which this sand is hurled against all obstacles in its path may be realized if one stoops down and faces it. The carving of the dead and living trees which are exposed to these natural sand-blasts is another evidence of their power. Fleshy fungi have been found growing on the windward side of logs and stumps completely petrified, as it were, by sand-blast action; sand grains are imbedded in the soft plant body and as it grows the imbedding is continued, so that finally the structure appears like a mass of sand cemented firmly together by the fungus. The bark of the common osier dogwood is red on the leeward side, but white to the windward because the colored outer layers of the bark have been wholly worn away. On the windward side of basswood limbs the softer portions are carved away while the tougher fibers remain as a reticulated network. On the leeward side of these same limbs, the outer bark is intact and even covered more or less with lichens.

The indirect action of the wind produces effects that are considerably more far-reaching than any other factor, for it is the wind which is primarily responsible for sand dunes and hence for their floras. But more directly than this, the wind plays a prominent part in modifying the plant societies of the dunes. The wind is the chief destroyer of plant societies. Its methods of destruction are twofold. Single trees or entire groups of plants frequently have the soil blown away from under them, leaving the roots exposed high above the surface ; as will be shown later this process is sometimes continued until entire forests are undermined, the débris being strewn about in great abundance. Again, swamps, forests, and even low hills may be buried by the onward advance of a dune impelled by the winds ; in place of a diversified landscape there results from this an all but barren waste of sand.

SOIL.

The soil of the dunes is chiefly quartz sand, since quartz is so resistent to the processes of disintegration. The quartz particles are commonly so light colored that the sand as a whole appears whitish ; closer examination reveals many grains that are not white, especially those that are colored by iron oxide. With the quartz there are conspicuous grains of black sand, largely hornblende and magnetite. These black grains often accumulate in streaks, persistent for considerable depths and apparently sifted by the wind ; large quartz grains are mingled with these grains of magnetite and hornblende so that it would seem as if grains of higher specific gravity are sifted out together with those of greater absolute weight. The sand of the dunes is remarkably uniform in the size of the particles as compared with beach sand ; this feature is due to the selective action of the wind, since the latter agent is unable to pick up and carry for any distance the gravel or large sand particles of the beach.

As is well known, soil made up chiefly of quartz sand has certain marked peculiarities which strongly influence the vegetation. The particles are relatively very large; hence the soil is extremely porous and almost devoid of cohesion between the grains. These features are of especial importance in their effect upon the water and heat relations as shown elsewhere. As a rule, sandy soils are poor in nutrient food materials, nor do they rapidly develop a rich humus soil because of the rapid oxidation of the organic matter.

WATER.

A factor of great importance, here as everywhere, is the water relation. Nothing need be said of atmospheric moisture, since that is sufficient to develop a rich vegetation if properly conserved, as is shown by the luxuriance of neighboring floras. Because of the peculiar physical properties of quartz sand, precipitated water quickly percolates to the water level and becomes unavailable to plants with short roots. The water capacity of sand is also slight, nor is there such pronounced capillarity as is characteristic of many other soils. Again, the evaporation from a sandy surface is commonly quite rapid. All of these features combine to furnish a scanty supply of water to the tenants of sandy soil. The rapid cooling of sand on summer nights may, however, result in a considerable condensation of dew, and thus, in a small way, compensate for the other disadvantages.

The ecological factors thus far mentioned act together harmoniously and produce a striking composite effect upon the vegetation. A flora which is subjected to periods of drought is called a xerophytic flora and its component species have commonly worked out various xerophytic structural adaptations of one sort or another. Again, a flora which is subjected to extreme cold, especially when accompanied by severe winds, takes on various structural adaptations similar to those that are characteristic of alpine and arctic floras. The dune flora is a composite flora, showing both xerophytic and arctic structures. In those situations which are most exposed to cold winds, one finds the best illustrations of the arctic type, while the desert or xerophilous type is shown in its purest expression on protected inland sandy hills. The discussion of the various arctic and desert structures and their relations to each other will be deferred to the second part of this paper.

OTHER FACTORS.

Certain other factors are of minor importance in determining the character of the dune flora. *Forest fires* occur occasionally, and, as will be shown later, they may considerably shorten the lifetime of a coniferous plant society.

Near cities the vegetation is unfavorably influenced by *smoke* and other products issuing from chimneys. In the neighborhood of the oil refineries at Whiting, Ind., the pine trees especially have been injured or destroyed. A careful study would probably show many plant species that have suffered a similar fate.

The *topography* is often a factor of considerable importance. Dune areas are conspicuous for their diversified topography. This factor determines to a great extent the water relation which has been previously considered, the hills and slopes being of course much drier than the depressions. The topography indirectly affects the soil, since it is mainly in the depressions that humus can rapidly accumulate. The direction of slope is a matter of importance, as will be shown in discussing the oak dunes; the greater exposure of the southern slopes to the sun results in a drier soil and a more xerophytic flora on that side.

Animals do not appear to exert any dominating influences on the dune floras. The dispersal of pollen and fruits by their agency is common here as elsewhere; so, too, the changes that animal activities produce in the soil. Near the cities the influence of man is seen, although such influences are slight unless the sand is removed bodily for railroad grading and other purposes.

The influence of *plants*, which so often becomes the dominant factor, is relatively inconspicuous on the dunes. The most important function which dune plants perform for other plants is in the contribution of organic food materials to the soil. The oxidation or removal of decaying vegetation is so complete on the newer dunes that the accumulation of humus is not important. On the more established dunes the mold becomes deeper and deeper, and, after the lapse of centuries, the sandy soil beneath may become buried so deeply that a mesophytic flora is able to establish itself where once there lived the tenants of an active dune. The advance of a wandering dune often results in the burial of a large amount of organic matter; when this matter becomes unburied years afterward it may again furnish a soil for plants. Many fossil soil lines have thus been uncovered on the Sleeping Bear dunes at Glen Haven, Mich.

IV. The plant societies.

A plant society is defined as a group of plants living together in a common habitat and subjected to similar life conditions. The term is taken to be the English equivalent of Warming's *Plantesamfund*, translated into the German as *Pflanzenverein*. The term formation, as used by Drude and others, is more comprehensive, in so far as it is not synonymous. It may be well to consider the individual habitat groups in a given locality as plant societies, while all of these groups taken together comprise a formation of that type, thus giving to the word formation a value similar to its familiar geological application. For example, one might refer to particular sedge swamp societies near Chicago, or, on the other hand, to the sedge swamp formation as a whole; by this application formation becomes a term of generic value, plant society of specific value.

Plant societies may be still further subdivided into patches or zones; the former more or less irregular, the latter more or less radially symmetrical. Patches are to be found in any plant society, where one or another constituent becomes locally dominant; zones are conspicuously developed on the beach and in sphagnous swamps. The term patch or zone has a value like that of variety in taxonomy. Authors disagree, here as everywhere, upon the content and values of the terms employed; this disagreement is but an expression of the fact that there are few if any sharp lines in nature. The above, or any other terminology, is largely arbitrary and adopted only as a matter of convenience.

In the following pages an attempt is made to arrange the plant societies in the order of development, the author's belief being that this order more faithfully expresses genetic relationships than any other. In the historical development of a region the primitive plant societies pass rapidly or slowly into others; at first the changes are likely to be rapid, but as the plant assemblage more and more approaches the climax type of the region, the changes become more slow. In the dune region of Lake Michigan the normal primitive formation is the beach; then, in order, the stationary beach dunes, the active or wandering dunes, the arrested or transitional dunes, and the passive or established dunes. The established dunes pass through several stages, finally culminating in a deciduous mesophytic forest, the normal climax type in the lake region. Speaking broadly, the conditions for plant life become less and less severe through all these stages, until there is reached the most genial of all conditions in our climate, that which results in the production of a diversified deciduous forest. On the beach there are to be found the most extreme of all xerophytic adaptations in this latitude, and, as one passes through the above dune series in the order of genetic succession, these xerophytic structures become less and less pronounced, finally culminating in the typical mesophytic structures of a deciduous forest.

A. THE BEACH.

As the author hopes to show in a subsequent paper, the beach formations of Lake Michigan are of two distinct types. One may be called the xerophytic beach, the other the hydrophytic beach. The conditions that determine these two types are not altogether clear, though their distribution suggests some factors which will contribute to the solution of the problem. Dunes are invariably absent from an area occupied by hydrophytic beaches, partly perhaps because hydrophytic beaches are seldom sandy, and partly because they are commonly found in protected locations. The hydrophytic beaches are found where the gradient of the lake bottom is very slight; as a consequence there is a wide zone of very shallow water in which typical swamp and shallow water plants flourish in great abundance. The bottom is very thickly strewn with gravel and shingle, closely resembling a reef in structure. On the other hand, a xerophytic beach is often sandy, is commonly associated with steep clay bluffs or dunes, and the gradient is much steeper, so that there is a comparatively narrow zone of shallow water. As a consequence, wave action is much more pronounced on the beach proper, as is shown by the great amount of driftwood stranded there. The scanty flora is in striking contrast to the diversified flora of the hydrophytic beach. The greater luxuriance of the flora on the hydrophytic beach is due, in part at least, to the greater freedom from the destructive action of the waves on account of the low gradient. The water supply is also conspicuously greater on the hydrophytic beach, again chiefly because of the low gradient. Inasmuch as dunes are associated only with the xerophytic beach, no further reference will be made to the other beach type.

The xerophytic beach is essentially a product of wave action and comprises the zone which is or has been worked over by the waves. Hence the beach may be defined as the zone between the water level and the topographic form produced by other agents; in the region under study the upper limit of the beach is commonly a fringe of sand dunes or a bluff of clay or gravel. The xerophytic beach in its typical expression is very naturally subdivided into three zones, which may be called the lower beach, middle beach, and upper beach. The lower beach is that zone which is situated between the water level and the line reached by the waves of common summer storms. The middle beach is the second zone, extending up to the line reached by the highest winter storms. The upper beach is essentially a former middle beach which is now beyond the reach of the waves, and yet is unoccupied by dunes or other topographic forms.

1. *The lower beach.*

The lower beach has been defined as the zone of land washed by the waves of summer storms. It might almost be defined as that portion of the beach which is devoid of vegetation. Perhaps there is no flora in the temperate zone quite so sparse as that of the lower beach, unless we except bare rocks and alkaline deserts. A survey of the life conditions in this zone reveals at once the reason for the scanty vegetation. Land life is excluded because of the frequency and violence of storms; the waves tear away the sand in one spot only to deposit it in another. Even though a seed had the temerity to germinate, the young plant would soon be destroyed by the breakers. Nor is there great likelihood that seeds will find a lodgment in this unstable location. As will be seen later the seeds ripened by tenants of the middle beach are almost entirely scattered away from the lake instead of toward it. The action of both wind and wave tends to carry seeds away from the lower beach. Again, few seeds could endure the alternate extremes of cold and heat, wetting and drying so characteristic of this zone.

Water life is excluded because of the extreme xerophytic conditions which commonly prevail on the lower beach. While algæ may propagate themselves in the shallow pools or even in the wet sand during a prolonged season of wet weather, a cessation of activity if not death itself soon follows the advent of dry weather. During a period of rainy weather in the autumn of 1897 green patches were observed in wet sand a few meters from the mouth of a creek near Porter, Ind. Microscopic observation showed that the green coloration was due to the presence of millions of motile Chlamydomonas forms. These unicellular biciliate algæ were in process of active locomotion in the water held by capillarity between the grains of sand. In all probability these forms migrated to the beach from the waters of the creek during a period of wet weather. It is possible that they might pass into resting stages and live through a season of drought were it not for the wind which gathers much of its dune material from the lower beach.

Thus the lower beach is a barren zone between two zones of life. Below it there exist algæ and other hydrophytic forms which flourish in the fury of the breakers; above it there exists the flora of the middle beach, a flora adapted to the most intense xerophytic conditions. At no particular time, perhaps, are the conditions too severe for some type of life; vegetation is excluded because of the alternation of opposite extremes.

2. *The middle beach.*

The middle beach is situated between the upper limits of the summer and winter waves, comparatively dry in summer but washed by the high storms of winter. It may also be defined as the zone of succulent annuals. The upper limit of this beach is commonly marked by a line of driftwood and débris. The instability of the beach conditions is often shown by the presence of a number of such lines, marking wave limits for different seasons. A very heavy storm will carry the débris line far up on the upper beach, to all intents and purposes carrying the middle beach just so much farther inland, as the flora of the next season testifies. Another season may be without the visitation of heavy storms and the middle beach will encroach upon the territory of the lower beach. The limits of the middle beach are altered more permanently by changes in the lower beach. In many places the lower beach is growing outwards, reclaiming land from the lake, while at other points the lake encroaches upon the land. Speaking broadly, the middle beach advances or recedes *pari passu* with the advance or recession of the lower beach. To some extent the débris lines register these changes, as their notable departure from persistent parallelism may indicate; however, there is a considerable lack of parallelism in the débris lines of a single season, owing to variations in the direction of the wind and other factors.

The life conditions in this zone are exceedingly severe, and result in a flora of the most pronounced xerophytic characters. The fury of the winter storms as they wash over the middle beach, tearing up here and depositing there, excludes almost entirely the possibility of survival through that period. In other words, biennials and perennials are practically excluded from maturing flowers and fruits, although their vegetative structures may flourish for a single season. In the summer the xerophilous conditions are extreme. Nowhere in the dune region are the winds more severe than here; the middle beach is close enough to the lake to feel all the force of its winds and yet far enough away for the wind to pick up sand from the lower beach and bring to bear upon the flora the intense severity of the sand-blast. No flora is more exposed to the extreme desiccating influences of the summer sun than that which grows upon the bare and open beach. Even though the roots can readily penetrate to the water level, the great exposure of the aerial organs to wind and sun results in the working out of that most perfect of all xerophytic organs, the succulent leaf. Just as succulent plants inhabit deserts where no other high grade plants can grow, so, too, they are able to withstand the severe conditions of the beach.

Along the entire eastern shore of the lake, the dominant plant of the middle beach is *Cakile Americana*. At many points this succulent crucifer is almost the only plant species found in this zone, and it is always the chief character species. Two other fleshy annuals are very common tenants of the middle beach: *Corispermum hyssopifolium* and one of the spurges, *Euphorbia polygonifolia*. It is a matter of interest to observe that two of these three character plants of the middle beach, Cakile and Euphorbia, are also characteristic inhabitants of the beach of the Atlantic coast. The significance of the presence of these and other marine forms along the shore of Lake Michigan will be discussed in another place. The above plants are rarely distributed uniformly over the middle beach. The favorite place for growth is along the lines of débris previously referred to; along these lines a greater number of seeds find lodgment than elsewhere, because the waves wash them up from lower levels and the protection of the driftwood prevents the winds from carrying them on farther. Then, too, the driftwood may furnish some protection to the growing plants, especially protection from winds which might otherwise uproot them. Cakile and Euphorbia reach their culmination on the beach, and when found farther inland it is chiefly on the upper beach or on windward slopes of active dunes. Corispermum, on the other hand, appears to be rather more characteristic of the active dunes than of the beach. Cakile is much the hardiest of the three species, venturing farther out toward the lower beach than either of the other two Of the three, Cakile is the most succulent and perhaps thus best adapted to the extreme xerophilous conditions to which beach plants are subjected. Euphorbia, however, has a copious supply of latex and its prostrate habit would seem to offer some advantages for existence on the beach. Cakile and Corispermum are readily dispersed by the wind, the latter by means of its winged seeds, while the former is a sort of tumbleweed; broken Cakile plants are common sights all over the dunes in the autumn and winter. Corispermum and Euphorbia become less and less common toward the north; at Charlevoix and Petoskey, Cakile is almost the only plant growing on the middle beach, and even this latter species is less common than farther to the south. Thus it seems as though the life conditions on the middle beach are more severe northward than southward, as indeed might be expected.

UNIVERSITY OF CHICAGC.

[*To be continued.*]

THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY—COLUMBIA MEETING.

THE second annual meeting of the Society for Plant Morphology and Physiology was held, along with the American Society of Naturalists and the affiliated societies, at Columbia University, Tuesday to Friday, December 27 to 30, 1898. On Tuesday evening a reception was tendered to the members of the society and visiting botanists by the Torrey Botanical Club, in the rooms of the Department of Botany of the University. The society joined with the other societies in the annual discussion on Thursday afternoon (upon advances in methods of teaching), and in the annual dinner of the affiliated societies on Thursday evening. On Friday morning an excursion was made to the New York Botanical Garden, where the grounds and buildings were shown by the director, Dr. N. L. Britton. At the business sessions of the society the following officers were elected for the ensuing year: president, J. M. Macfarlane; vice presidents, G. F. Atkinson and D. P. Penhallow; secretary, W. F. Ganong. The following new members were elected: F. C. Stewart, C. O. Townsend, F. C. Newcombe, B. D. Halsted, J. B. Pollock, D. S. Johnson, L. M. Underwood, M. B. Waite. The sessions for the reading of papers were presided over by the president, Dr. W. G. Farlow. The presidential address, on "Peculiarities of the Distribution of Marine Algæ in North America," was delivered at 4:00 P.M., on Thursday. It is hoped that it will soon be published in full. The following papers were presented, the abstracts having been prepared in every case by the authors:[1]

W. F. GANONG, *Secretary.*

Some peculiar morphological structures in Paulownia imperialis: JOHN W. HARSHBERGER, University of Pennsylvania.—*Paulownia*

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[1] The condensation of some of these abstracts has been necessary on account of our limited space.—EDS.

imperialis, a Japanese tree of dense umbrageous habit, is interesting botanically from several standpoints. The method of branching is sympodial. The main shoot is terminated by an inflorescence, which dies back, after the seeds are discharged, to an axillary bud that prolongs the growth the next season. The flower buds, which are grouped in dichotomous cymes approaching the scorpioid form, are protected during the winter by the fleshy calyx and dense ferruginous hairs. The flowers, which expand in spring, are fully formed within the sepals. The leaves also are hirsute, and are thus protected from the full force of the sun's rays. The fruit, which discharges in midwinter the winged seeds, is provided with a fleshy cushion that contains a considerable quantity of tannin. It is possible that this tannin is a reserve product, for when the seeds are ripe and the cushion falls out, there is not a trace of tannin left. The petiole contains a large number of crystals of calcium oxalate surrounding the hard bast. The different forms of these crystals are probably due to varying conditions of metabolism in the autumn, since the forms of crystals may be made to vary by altering the conditions of crystallization.

The life-history of Leuchtenbergia principis: W. F. GANONG, Smith College.—The life-history of this most noteworthy of the Cactaceæ has hitherto been quite unknown. Seeds and young plants obtained from Mexico have enabled the author to work out the anatomical and morphological development through all stages except that from the opened flower to the ripe fruit. The paper discusses the history of our knowledge of the species, gives a full description of it, an account of its geographical distribution, its habits and ecology, its morphological composition as determined by comparative anatomy and embryology, the precise internal anatomy of the adults, and of the parts unfolding from the vegetative points and of the embryos in their unfolding from the seed to the adults. This work is intended by the author as the first of a series of life-histories of members of this family, which are expected to yield data for a better understanding both of the phylogeny of the genera and of the principles of morphology and ecology illustrated by this highly specialized family.

Root tubercles upon spring and autumn grown legumes: B. D. HALSTED, New Jersey Agricultural College.—The ninth successive crop of wax beans upon the same plot, grown in the spring, consisted of plants whose roots were abundantly supplied with large, nearly spherical tubercles. The plants of the succeeding crop grown in the summer upon the same soil had very few tubercles. The cause of this difference was sought in the soil conditions. During the early growth of the spring plants the soil was considerably cooler than in August when the second crop was passing through the initial stages of development. There was, doubtless, also less available soil nitrogen in the comparatively cool earth of May than in the warmer ground of August. The nitrifying germs, being more active in midsummer, provided a daily supply of combined nitrogen for the young plants. The spring crop, not having this ample supply, was "nitrogen-hungry," and this furnished the proper condition for the abundant development of the tubercles. Successful inoculation of the plants with soil-extract or the pure culture of the tubercle germ, "nitragin," is dependent largely upon soil conditions and many widely varying results may thus find an explanation.

Further notes on the comparative embryology of the Rubiaceæ: F. E. LLOYD, Teachers College.—The genera studied include Houstonia, Rubia, Sherardia, Vaillantia, Crucianella, Galium, and Asperula.

In the hypoderm of the nucellus eight or ten macrospores develop. Many of them germinate, becoming quadrinucleate One, sometimes two, become perfect embryo-sacs, with antipodals in all forms studied, a fact hitherto unrecognized, excepting in Houstonia. One of the antipodals is very large, comprising the whole lower half of the embryo sac in Sherardia, Rubia, and Galium. The condition in Asperula is not completely clear, but the writer thinks that a larger number of antipodals are present as in certain Compositæ. The suspensor is divided into two regions, micropylar and embryonal. The latter is composed of disk-shaped cells; the former of large cells swollen out laterally, forming absorbing organs which become applied to the endosperm. A free preparation of these structures resembles a bunch of grapes, a condition similar to that described for Sutherlandia by Hofmeister and Guignard. The integument becomes absorbed, the seed-covering consisting of the pericarp and a single layer of cells derived from the integument.

Inflorescences and flowers of Polygala polygama: CHARLES H SHAW, University of Pennsylvania.—In addition to the well-known pink-purple aerial and subterranean cleistogamic flowers, an exactly intermediate type is developed on special inflorescences. These are green aerial cleistogamic flowers, borne on shoots which, though produced considerably above ground, are slightly or strongly geotropic. A detailed account of the differences between the three types was given.

Observations on the development of some monocotyledonous embryo sacs: R. E. B. MCKENNEY, University of Pennsylvania.—The development of the embryo-sac in two species of Scilla, *S. hyacinthoides cærulea* and *S. campanulata* was described in detail, while reference was made to Lilium. No centrosomes were observed during the resting condition of the nuclei or during mitosis.

The structure and relation of the crystal cells in sensitive plants: R. E. B. MCKENNEY, University of Pennsylvania.—The crystal cells in sensitive plants form a complete sheath around the bundle cylinder of stems and a half-sheath around the phloem side of leaf bundles. Each cell of the sheath contains a single large hexagonal crystal. The crystals seem to be rather insoluble silicates. The crystal cells have a very small enucleolate nucleus, no vacuoles, and no starch. The crystals make their appearance first in the cells at the distal end of the bundles of the first foliage leaf and are formed basipetally. The more sensitive plants have the crystals either more abundant or better developed than the less sensitive plants, and *vice versa.*

Structure and parasitism of Aphyllon uniflorum: AMELIA C. SMITH, University of Pennsylvania.—The most conspicuous features of this plant, as thus far worked out, are as follows: (1) Its parasitism on *Aster corymbosum*, and the degeneration attendant upon its parasitic habit, as expressed by: (*a*) absence of chlorophyll; (*b*) degeneration of leaves; (*c*) loss of root-hairs and probably of root-cap; (*d*) reduction and degeneration of the bundle system, and greater relative development of phloem than of xylem; (*e*) small size of seed, primitive embryo, and development of this embryo within mass of (probably) precocious endosperm. (2) Stomata, where present, are on the more exposed places, *i. e.*, outer surfaces of upper bract-leaves, upper part of flower-stalk, outer sufaces of calyx and corolla. (3) Starch is present in great quantities in roots, stems, leaves and carpellary tissue.

On the occurrence of tubers in the Hepaticæ: M. A. HOWE, Columbia University.—In none of the standard text-books does there appear to be any allusion to such structures. The number of known tuber-bearing species at the present time is at least eleven; of Anthoceros four, Riccia three, Petalophyllum two, Fossombronia one, and Geothallus one. As the Hepaticæ of the drier regions become better known this adaptation to drought will probably prove more common than now generally supposed. In the Californian *Anthoceros phymatodes*, the tuber first appears as a swelling near the apparent apex of a costa-like thickening of a thallus segment, becoming later strictly ventral through the continued onward growth of the segment, and coming at the same time to be pendent from the ventral surface through the formation of a peduncle. The body of the tuber consists of a cortex of two to four layers of nearly empty cells enclosing a mass of smaller cells so densely filled with oil-drops or nearly colorless granules that the cell-boundaries are obscure. Ashworth finds aleurone-grains and oil-drops in the interior cells of the tubers of the Australian *Anthoceros tuberosus*. The reserve food-materials in the tubers of the Californian plant seem to take the same forms. There is very little, if any, starch. In two cases the old tubers of *Anthoceros phymatodes* have been found sending out new shoots, demonstrating that they play a part in the vegetative propagation of the plant, a function which had been only inferred in the three tuber-bearing species of Anthoceros previously known.

Morphology of the genus Viola: HENRY KRAEMER, Philadelphia College of Pharmacy.— The author has examined style and stigma, staminal and corolline hairs, pollen grains, and bracts in about thirty species of the genus Viola, chiefly found in the United States.

He distinguishes one group by its nearly globular stigma with more or less developed lip-like appendage, style with a knee-like bend, and characteristic corkscrew shaped hairs on the spurred petal. This group includes *V. heterophylla*, *V. lutea*, *V. tricolor* and its varieties.

The remaining species are subdivided into five groups, according to the length of the nectar-secreting spur of the stamen.

The influence of electricity upon plants: G. E. STONE, Massachusetts Agricultural College.—This paper contained the results of experiments based upon measurements of about 20,000 plants, and was illustrated by a dozen diagrams containing tables and growth curves showing the manner of response in plants to electrical stimuli. A brief outline of the history of electrical experiments was given, together with a discussion of the imperfections of the methods which have been employed by experimenters. Various kinds of currents were employed and data showing the relative effect of each upon germination and growth were presented. A brief résumé of some of the more important results are as follows: (1) Electricity exerts an appreciable influence upon plants. (2) The application of certain strengths of current for a short time (one minute or less) is sufficient to act as a stimulus. (3) Germination and growth are both accelerated by electricity. (4) Electrically stimulated plants do not respond immediately but possess a latent period of about twenty-five minutes, *i. e.*, about the same as that for heliotropic and geotropic stimuli. (5) Reaction to electrical stimulation is limited to a narrow range in current intensity. The reaction is manifested either in an acceleration or retardation of metabolic activity, according to the nature or the strength of the current employed. (6) There is a minimum, optimum, cessation, and maximum stimulus. (7) The excitation produced by alternating currents is more marked than that produced by direct currents. (8) The increase of stimulus necessary to produce an equally noticeable difference of perception bears a constant ratio to the total stimulus intensity; the relationship existing between the perception and stimulus is expressed by the ratio 1 : 3 (Weber's law).

Some notes upon the germination of spores: C. O. TOWNSEND, Maryland Experiment Station.—Experiments were undertaken to determine the effect upon germination of keeping spores in distilled water under different conditions of temperature and light. Spores of Mucor, Penicillium, and other fungi were placed in test-tubes partly filled with distilled water. Some tubes were subjected to the out-door changes in temperature; others were kept at a nearly constant temperature of 18° in diffused light; others at the same temperature in the dark; and still others at 25° in the light. The spores were tested from time to time by removing a few from each set of tubes and placing them upon a mixture of gelatine and sugar in moist chambers. So long as the spores that were exposed to the natural fluctuations of temperature did not freeze they retained their ability to germinate in the usual time (12–16 hours). After freezing, however, they did not germinate. The other spores retained for at least six months their ability to germinate in the usual time. The growth of the mycelia and the ability to form new spores were not affected.

Sensitiveness of certain parasites to the acid juices of the host plant: ERWIN F. SMITH, Department of Agriculture.—The comparatively slow progress of *Pseudomonas campestris*, *P. phaseoli*, and *hyacinthi* when inoculated into the host plants, even in enormous numbers, led to the belief that the restraining influence must be the acid juices of the cabbage, the bean, and the hyacinth. Experiments tend to establish this fact more definitely. All the fluids tested, hyacinth broth, cabbage juice, tomato juice, potato broth, acid beef broths, malic acid broths, etc., were titrated with caustic soda and phenolphthalein so that in each case the exact grade of acidity which retarded or inhibited growth is known definitely. This paper will soon appear in full as part of the larger work dealing with the parasitic nature and life history of Wakker's hyacinth bacterium.

Further observations on the relations of turgor to growth: CARLETON C. CURTIS, Columbia University.—Experiments were undertaken to determine the time limit for the renewal of growth after changing the concentration of the nourishing substratum, and also for testing the turgor force at the moment of renewal. Species of Mucor, Penicillium, and Botrytis were used. They were grown in respectively a nourishing solution, a nourishing solution with the addition of 4, 9, 14, and 20 per cent. KNO_3. Penicillium in the solution with no KNO_3 had a turgor force of 7.5 ($NaNO_3$ being used as a test); in a 20 per cent. solution, 42.5. In changing from 0 to 20 per cent., growth ceased for from 8 to 12 hours. When it began the turgor force in the majority of cases appeared normal, *i. e.*, 42.5. In changing from 30 per cent. to 0, growth ceased for 30 to 45 minutes, when it resumed growing at the normal turgor force (7.5). So with the lesser changes, *i. e.*, from 0 to 4 per cent., recovery occurred in about one hour, turgor force normal (12); change from 4 per cent. to 0, recovery in about 15 minutes, turgor 7.5, and so on. Botrytis gave practically the same results. Mucor was much more sensitive, having a lower turgor force, and would not tolerate a change to higher than a 4 per cent. solution, but in other respects it behaved as the others. Experiments are being conducted with other salt solutions, and also upon higher plants. As regards KNO_3 it would seem that turgor is a controlling force in growth. The check due to increasing the turgor corresponds to the shock due to cutting a hypha, inhibiting growth for a time.

Symbiosis and saprophytism: D. T. MacDougal, University of Minnesota.—The terms saprophyte and holosaprophyte should be applied to those forms which derive their food supply from organic products directly, without the aid of mycorhiza, tubercles, etc. This category includes numerous bacteria, fungi, and but two seed-forming genera, Wullschlægelia, and Cephalanthera. The last named has been added by recent investigations of the author. The extension of the saprophytic capacity of seedlings results in the reduction of the seeds, and may also be prolonged to include the entire life history of the sporophyte.

Influence of inversions of temperature and vertical air-currents upon the distribution of plants: D. T. MacDougal, University of Minnesota.— As a consequence of the rapid radiation from the soil and low conductivity of dry air, the lower layers of air are cooled much more rapidly than the upper layers. In broken regions the cooled air flows down into the valleys, giving them a lower minimum than that at the adjoining hills. The diurnal ascending currents give the hills a lower maximum than the valleys. A valley at Flagstaff, Ariz., showed a temperature [illegible] to 27° F. below that of an adjoining hill at night, and was 3° to 5° warmer in the day. As a consequence, the average temperature of the valley will be lower than that of the adjoining hills and the temperature of the hills will be more equable than that of the valley, provided the difference in elevation be less than 1000^{ft}. At this and greater differences of height the disturbing factors of increased insolation, effect of altitude, and expansion and compression of the atmosphere come into play. The expansion and cooling of ascending currents of air increase the humidity, and thus give certain local ridges and rims of mesas a comparatively moist atmosphere. According to the laws influence of temperature upon distribution, and supported observations of the writer in the southwest, also by the results of Professor Townsend, the following conclusions are reached: (1) Inversions of temperature and resulting air-currents minor highlands a much more equable temperature than adj ing hills and cañons. In North America such effects are most marked on the elevated plains of the southwest. (2) Inversions of temperature would result in major deflections of zonal boundaries on great level plains, and constitute a hitherto unrecognized factor in distribution. (3) Inversions of temperatures and the resulting air-currents cause abrupt deflections of the zonal boundaries corresponding to minor topographical features. Southern forms reach their extreme northernmost extension along ridges and hills. Northern forms penetrate farthest southward down valleys or cañons. (4) Ascending currents of air furnish conditions favorable to the growth of moisture-loving species along the margins of table lands bordering on valleys and cañons.

Some appliances for the elementary study of plant physiology: W. F. GANONG, Smith College.—The author pointed out that investigation is greatly aided by the wide diffusion of its results through good elementary teaching, and that the rapid introduction of plant physiology into elementary courses in botany is making a demand for simpler, less expensive and more conclusive experiments. The author then described some simple appliances developed in his physiological practicum in Smith College. These included a simple temperature stage for study of the relation of temperature to protoplasmic movement, by use of which very accurate quantitative results may be obtained; a clinostat constructed from clockwork and ample for demonstrating the principles of geotropism, etc.; a self-recording auxanometer, simple and inexpensive but yielding sufficiently accurate results for elementary work; an osmometer, using Schleicher & Schüll's diffusion shells 16^{mm} diameter in combination with burettes, giving very pronounced results; a simple new method of demonstrating the exchange of gases in respiration; an inexpensive germination box; a useful way of preparing a plant for transpiration experiments; an excellent way of graduating roots, etc., by the use of a stretched thread along which insoluble India ink is allowed to run by capillarity. A description of these appliances will be published later.

Some notes on the reproduction and development of Nereocystis: CONWAY MACMILLAN, University of Minnesota.—(Abstract not furnished.)

The formation and structure of the dissepiment in Porothelium: E. A. BURT, Middlebury College.—The author traced the development of the fructifications of *Porothelium fimbriatum* Pers. from their origin as papillæ, through the pore, to the tube stage; in the latter stage contrasting the structure of the dissepiment where the tubes are closely crowded together with its structure where they are more scattered.

Gelatin culture media: ERWIN F. SMITH, Department of Agriculture.—Dr. Smith spoke on gelatin culture media, illustrating his remarks by photographs, charts, etc. The behavior of many sensitive organisms, particularly parasites, depends entirely on how the nutrient gelatin is compounded, and consequently this should always be stated. (1) The melting point of nutrient gelatins increases as more gelatin is added. It decreases on addition of acids and alkalies and by long boiling. (2) Grape sugar or cane sugar added to nutrient gelatin frequently restrains or entirely prevents liquefaction, while at the same time it stimulates growth. For this reason gelatin should be made with beef broth free from sugar. (3) Owing to the fact that commercial gelatin contains acid salts, which are neutral or alkaline to litmus but retard the growth of many organisms, the gelatin media should first be rendered neutral to phenolphthalein, after which if desired, it may be acidified with particular acids. A commercial gelatin of uniform character and washed free from all inhibiting acid substances is a desideratum.

Notes on the relative infrequence of fungi upon the trans-Missou plains and the adjacent foothills of the Rocky mountain reg CHARLES E. BESSEY, University of Nebraska (Abstract sented by ERWIN F. SMITH).—In the districts named a stud fourteen years has shown the species of fungi to be numer while the number of individuals is comparatively small, the ex opposite being true of the flowering plants, especially of th baceous sorts. This scarcity of individuals is especially marked in case of the higher fungi.

Different types of plant diseases due to a common Rhizoctonia: B. M. DUGGAR, Cornell University, and F. C. STEWART, New York Experiment Station.—A number of species of the sterile fungus Rhizoctonia have long been known as root parasites on a wide range of host plants. (1) Studies on a damping-off fungus of various seedlings have located the cause of the disease as a species of Rhizoctonia. (2) A fungus agreeing in structure with the latter has been the cause of a serious root-rot of sugar beets in New York during the past year, and the fungus identified with this disease seems to be undoubtedly *Rhizoctonia Betæ* Kühn. (3) An important stem-rot of carnations is also found to be due to a fungus agreeing precisely in its characters with the beet Rhizoctonia.

That the organism mentioned in each case is the cause of the trouble indicated has been demonstrated by experiment. Again, there is abundant experimental proof showing that the beet fungus and the carnation fungus are identical. The last named fungi also produce damping off, although not so abundantly as the fungus originally isolated from damped-off seedlings. Experiments, however, indicate that these different types of diseases are all due to the same species of Rhizoctonia, the specific affinities of which cannot now be given with certainty. Peculiarities in branching, and the formation of tuft-like masses of hyphæ, or of sclerotia, readily identify this fungus. Its sensitiveness to alkaline nutrient media suggests the preventive treatment.

The stem-rot diseases of the carnation: F. C. STEWART, New York Experiment Station.—Under the names "stem-rot," or "die-back," at least two distinct diseases have been confused. One is caused by Rhizoctonia; the other is due to a Fusarium, and is, perhaps, identical with Sturgis' carnation stem-rot. Both diseases are common in the field and greenhouse.

The Fusarium attacks chiefly the stem and larger branches, discoloring the wood and killing the cortex, but rarely causing a soft rot. The affected plants die gradually with yellowing and drying of the foliage. The fungus rarely fruits on the outside of the stems, but more frequently in the cambium and pith of stems long dead.

The Rhizoctonia causes the plants to wilt suddenly by rotting the stem at or just below the surface of the soil. The cortex readily separates from the wood, the pith is attacked quite early, becoming water-soaked in appearance (corky when dry) and filled with hyphæ.

BRIEFER ARTICLES.

NOTES ON THE MAXIMUM THERMAL DEATH-POINT OF SPOROTRICHUM GLOBULIFERUM.

WHILE engaged in a study of an entomogenous fungus, *Sporotrichum globuliferum*, as an economic factor in the destruction of the chinch-bug, some experiments were made for the determination of the maximum thermal death point of this fungus under various conditions. The experiments were necessarily concluded when only some of the more evident results of higher temperatures had been secured as preliminary to more accurate investigations. Since it proved impossible to continue this work much further under similar conditions, some preliminary data are presented which are at least suggestive at times.

The original culture of the fungus was secured from a beetle, and the fungus is undoubtedly that which has been determined by Thaxter[1] as *Sporotrichum globuliferum* Speg. The cultures used in this experiment are one remove from stock tubes secured from the above mentioned dilution culture. All cultures were made on nutrient agar in slanting tubes, and every lot exposed to high temperatures was accompanied by checks at the room temperature. Since the checks constantly gave uniform growth, they are not included. Moreover, exposed tubes in which growth had failed were constantly re-inoculated and tested at room temperatures, and in all cases growth resulted.

In estimating quantity of growth it is difficult, with such tube-culture experiments, to make close comparisons in any case, and especially so where there is no distinct line of growth, but only several isolated centers. All sowings were made as streak cultures with an abundance of spores on the needle, and discrepancies might occasionally arise from the fact that spores adhering in small masses might be less penetrated by moisture, and hence more liable to survive.

In general, the approximate length of exposure required to cause death at the various temperatures is plainly indicated in the tables, and comment is unnecessary. Some details, however, may be noticed in connection with the tables.

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[1] Seventeenth Report of the State Entomologist of Illinois, S. A. Forbes, 1895–6.

From drop cultures it was ascertained that germination might begin in a few hours; and in twenty-four hours there was considerable germination and growth about the spores. Again, at a uniform temperature, in two and one-half days, considerable aerial mycelium was developed, but rarely any spores, and this stage of growth was taken as the age limit for tests upon mycelium. (See table VI.)

For the tests with dry spores, as in table VII, fresh spores were exposed on glass slips, and then inoculations were made immediately therefrom.

TABLE I.

35° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
1	Immediately	6 hours		Good growth
2	"	24 "		One center
3	"	Continuously		No growth
4	6 hours	24 hours		Good growth
5	24 "	24 "		Good growth
6	Immediately	6 "	2	Good growth
7	"	6 "	4	Good growth

It is of some interest that even at 35° an exposure of 24 hours quite effectually inhibits growth, when immediately exposed to the temperature (see exp. 2); while a few hours after germination may have begun, the same did not hold true.

TABLE II.

37.7° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
8	Immediately	6 hours		Good growth
9	"	9 "		Good growth
10	"	18 "		Good growth
11	"	24 "		No growth
12	"	Continuously	One week	No growth
13	6 hours	24 hours		Good growth
14	15 "	24 "		Good growth
15	24 "	24 "		Good growth

The results at 37.7° C. repeat and confirm those of table I, in that freshly sown spores are readily killed in twenty-four hours, while those which have lain some hours in conditions favorable for germination are capable of further growth after exposure.

TABLE III.

40.5° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
16	Immediately	6 hours		Good growth
17	"	9 "		Good growth
18	"	18 "		Good growth
19	"	24 "		No growth
20	"	Continuously		No growth
21	6 hours	6 hours		Good growth
22	15 "	6 "		Good growth
23	24 "	6 "		Good growth
24	6 "	24 "		One center
25	15 "	24 "		Two centers
26	24 "	24 "		No growth
27	Immediately	3 "	2	Two centers
28	"	3 "	4	No growth
29	"	6 "	2	No growth
30	"	6 "	4	No growth

TABLE IV.

46.1° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
31	Immediately	1 hour		Good growth
32	"	3 hours		Few centers
33	"	6 "		No growth
34	"	9 "		No growth
35	"	18 "		No growth
36	6 hours	1 hour		Good growth
37	15 "	1 "		Good growth
38	24 "	1 "		Good growth
39	6 "	3 hours		Fair growth
40	15 "	3 "		Good growth
41	24 "	3 "		Good growth
42	6 "	6 "		One center
43	15 "	6 "		Three centers
44	24 "	6 "		Six centers
45	6 "	12 "		Three centers
46	15 "	12 "		Four centers
47	24 "	12 "		No growth
48	6 "	24 "		No growth
49	15 "	24 "		One center
50	24 "	24 "		No growth
51	Immediately	1 hour	2	No growth
52	"	1 "	4	No growth

TABLE V.

51.6° C. AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Successive days	Result
53	Immediately	1 hour		Four centers
54	"	3 hours		No growth
55	"	6 "		No growth
56	6 hours	1 hour		Six centers
57	15 "	1 "		One center
58	24 "	1 "		No growth
59	6 "	3 hours		One center
60	15 "	3 "		No growth
61	24 "	3 "		No growth
62	6 "	6 "		No growth
63	15 "	6 "		No growth
64	24 "	6 "		No growth
65	Immediately	1 hour	2	No growth
66	"	1 "	4	No growth

TABLE VI.

MYCELIUM, AGAR CULTURES.

Exp. no.	When exposed, after sowing	Length of time exposed	Temperature, deg. C.	Successive days	Result
67	2½ days	6 hours	37.7		New growth
68	2½ "	24 "	37.7		New growth
69	2½ "	6 "	40.5		New growth
70	2½ "	24 "	40.5		New growth
71	2½ "	6 "	40.5	2	Four centers new growth
72	2½ "	6 "	40.5	4	No new growth
73	2½ "	1 hour	46.1		New growth
74	2½ "	3 hours	46.1		New growth
75	2½ "	6 "	46.1		Fair new growth
76	2½ "	12 "	46.1		Three centers new growth
77	2½ "	24 "	46.1		No new growth
78	2½ "	1 hour	46.1	2	New growth
79	2½ "	1 "	46.1	4	Few centers new growth
80	2½ "	3 hours	46.1	2	New growth
81	2½ "	3 "	46.1	4	One center new growth
82	2½ "	6 "	46.1	2	One center new growth
83	2½ "	6 "	46.1	4	No new growth
84	2½ "	1 hour	51.6		New growth
85	2½ "	3 hours	51.6		New growth
86	2½ "	6 "	51.6		No new growth
87	2½ "	12 "	51.6		No new growth
88	2½ "	24 "	51.6		No new growth
89	2½ "	1 hour	51.6	2	No new growth
90	2½ "	1 "	51.6	4	No new growth

Table III shows less difference between immediate and delayed exposures to the higher temperature.

In table IV it is again evident that longer exposures were necessary to kill all of the spores when germination might have begun.

The limits of growth in table V are very well indicated, and the effects of immediate and delayed exposures are for the first time practically the same.

TABLE VII.

SPORES EXPOSED TO DRY HEAT.

Exp. no.	Length of time exposed	Temperature	Successive days	Result
91	6 hours	51.6		Good growth
92	3 "	54.4		Good growth
93	6 "	54.4		Good growth
94	1 hour	60		Good growth
95	6 hours	46.1	2	Good growth
96	6 "	46.1	4	Good growth
97	3 "	51.6	2	Ten centers of growth
98	3 "	51.6	4	No growth

Unfortunately the maximum amount of dry heat which the spores of this fungus will resist during a single exposure was not ascertained.

Below are given some results at various temperatures with the mycelium of this fungus when grown upon chinch-bugs.

TABLE VIII.

MYCELIUM, CULTURES ON INSECTS.

Exp. no.	Growth	Length of time exposed	Temperature Deg. C.	Successive days	Result
99	Mycelium	6	46.1		New growth on some
100	"	24	46.1		New growth on some
101	"	3	46.1	4	New growth on some
102	"	6	46.1	4	New growth on some
103	"	3	51.6		New growth on all
104	"	6	51.6		New growth on some
105	"	1	51.6	4	New growth on some
106	"	3	51.6	4	New growth on all

In the experiments of table VIII, a number of dead bugs were dusted with the spores, and in a day or so, when there was considerable aerial growth of mycelium along the body sutures, exposures were made. The thermal death point was not ascertained, but it is evidently much above that of the mycelium grown upon agar (see table VI). The fact that new growth, or further growth, did not appear upon some of the insects was expected, since sterilization precautions could not there be observed, and foreign molds were sometimes present.— B. M. DUGGAR, *Cornell University, Ithaca, N. Y.*

DESCRIPTIONS OF TWO WILLOWS FROM CENTRAL MEXICO.

(WITH FIGURES 1, 2.)

THE two willows here described were collected by Mr. Pringle at Sierra de Ajusco in the state of Mexico. They were collected at an altitude of 10,000 feet. The descriptions of Mexican willows are meager and imperfect. Anderson in the Prodromus gives them very little attention, probably having only scanty material from that region, and with very little literature from which to make up descriptions.

The writer wishes to express his gratitude to Dr. Robinson and Mr Greenman of the Gray Herbarium not only for the opportunity to study the specimens but also for much information regarding the Mexican species.

Salix Pringlei, n. sp.— Shrub 1 to 2^{m} high: twigs of season's growth minutely hoary puberulent, older shoots dull olive green or brownish: leaves in vernation densely tomentose and slightly ferruginous, at maturity becoming nearly glabrous and dark green above, paler and velvety tomentose beneath, entire (or obscurely crenate on vigorous young shoots), elliptical, acute at both ends, largest 6^{cm} by 2^{cm}, on petioles 5^{mm} long; stipules none: pistillate ament at anthesis nearly sessile in its leafy bracts, 2^{cm} long by 1^{cm} thick, subcylindrical: young capsule ovate-lanceolate, densely tomentose, grayish, 3^{mm} long, very short pedicelled; scale twice the length of the pedicel, elliptical, black, with rather long crisp hairs on its margin; gland small, one half as long as the pedicel; style very short; stigmas bifid: pistillate aments at maturity large (6–8^{cm} long by 2^{cm} thick), on short leafy peduncles less than a centimeter long bearing 3 or 4 small green leaves: mature capsules lanceolate conical on glabrous pedicels.

This description is based on Mr. Pringle's no. 6795. No staminate plant was collected. The species is related to *S. candida* which resembles in the general characters of the ament and the aspect of the whole plant. It differs from that species, however, in having broader leaves, not at all revolute nor rugose, no stipules, pedicel longer than the gland, style and stigmas relatively short. *S. paradoxa* Kunth differs from this species in having "capsulæ hirsutæ longe pedicellatæ, stylo nullo."

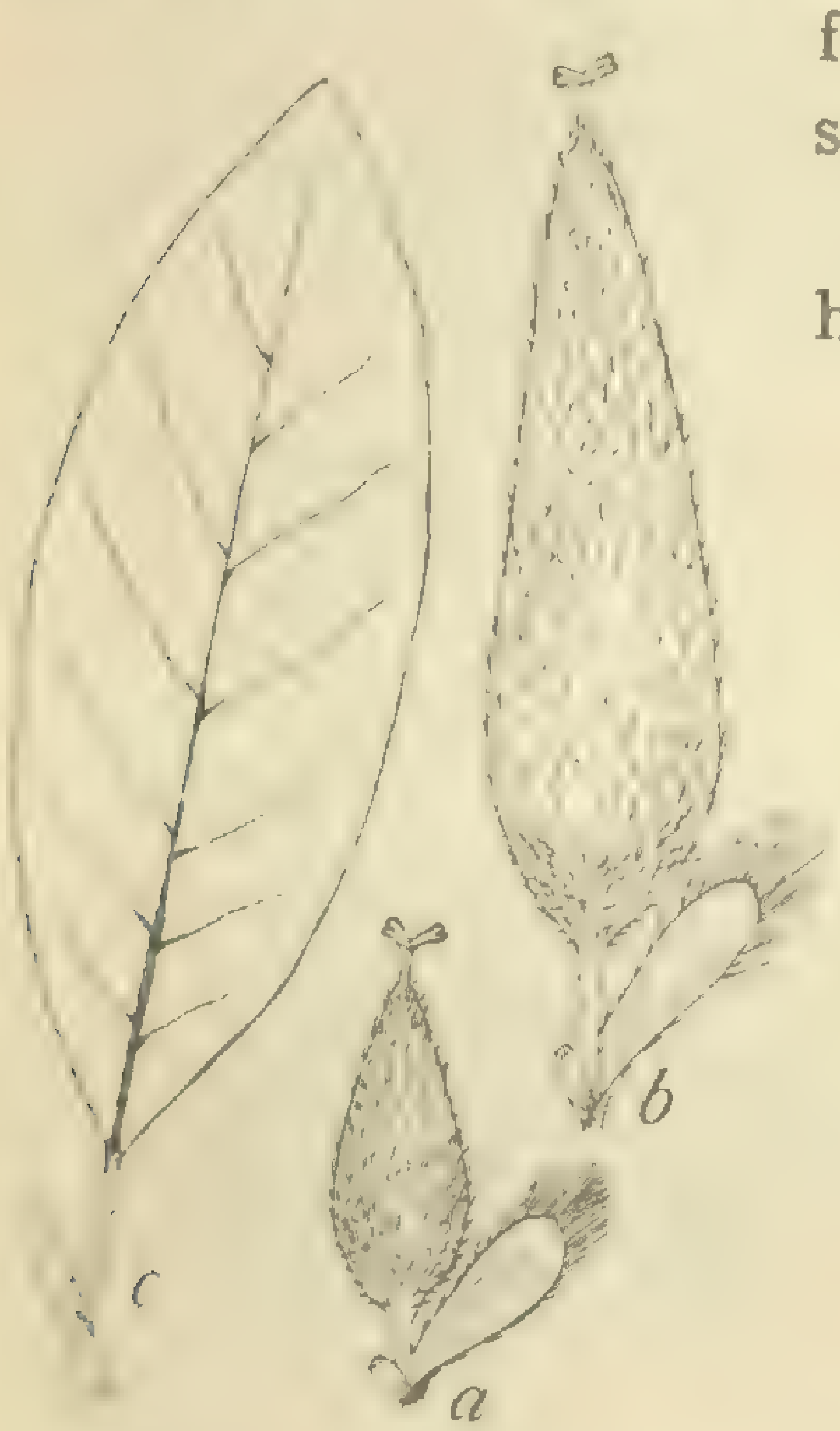

FIG. 1.—*Salix Pringlei.* *a* young capsule, with scale and gland; *b* mature capsule; *c* leaf.

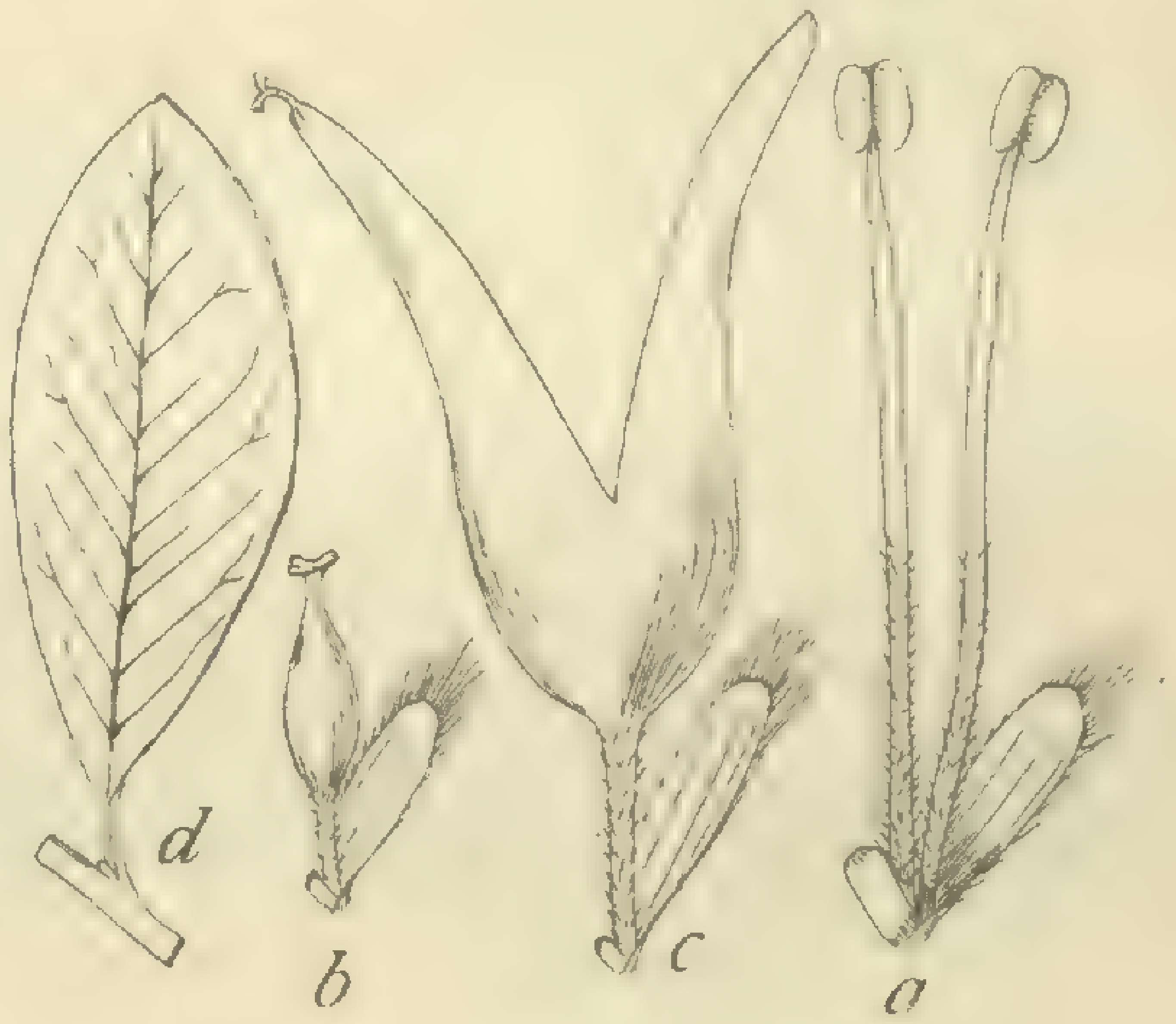

FIG. 2.—*Salix cana* Mart. & Gal. *a* ♂ flower; *b* young capsule; *c* mature capsule, dehisced; *d* leaf.

S. CANA Mart. & Gal.—Tree 5–7^{m} high: twigs scantily canescent, older shoots stout black and glabrous: leaves in vernation densely flocculent tomentose, becoming glabrous or nearly so when mature, green above, glaucous and prominently veined beneath, obovate or elliptical, apex acute or short acuminate, acute or rather abruptly contracted at base, entire, largest 6^{cm} long by 2^{cm} wide; petioles hairy, 5^{mm} long; stipules minute or wanting: staminate aments large (3^{cm} by 1^{cm}); stamens two, filaments hairy below; scale obovate, apical half dark brown, ciliate; gland large, one half as long as the scale: mature pistillate aments large (7^{cm} by 2^{cm}), nearly sessile; peduncle at maturity only 1^{cm} long and bearing four or five small leaves, rather closely flowered; full grown capsule (8^{mm} long) ovate-conical, glabrous, minutely roughened; pedicel (2^{mm}) hairy, gland less than one-half the length of the pedicel: bract oblong, slightly longer than the pedicel; style short (0.5^{mm}). A capsule aborted at anthesis indicates that the bract is then about twice the length of the pedicel.

The original description of this species, as given in *Bull. Acad.*

Brux. **10**: —, is based on a leafy specimen, the authors' own statemen being "amenta ignota." Their description does not disagree with ou plant, and the fact that both were collected in the same region an approximately at the same altitude, warrants the conclusion that the belong to the same species.

As will be seen, the above description is drawn from a staminat branch at anthesis and a pistillate branch when the capsules are matur They are Mr. Pringle's no. 6794.

This species belongs to the *Cordata* group and is closely related t *S. lasiolepis* of California, from which it differs in having free hai filaments, hairy pedicels, elliptical leaves, and large catkins.—W. W ROWLEE, *Cornell University.*

A PECULIAR CASE OF SPORE DISTRIBUTION.

(WITH FIGURE 1.)

THE manner in which the spores of fungi may be distributed clearly shown in a case which came under observation last Septemb in Columbus, Ohio. A grape vine, quite thoroughly infested with t mildew, *Uncinula necator* (Schw.) Burr., showed its characteristic c cular spots in profusion. This was the condition over about two-thir of the one affected vine, and the appearance of these leaves is shown *a*, *fig.* 1. In the remaining third of the leaves the fungus forsakes habit of concentric growth and follows a tortuous path, of the great irregularity and grace, as shown in *b* and *c*, *fig.* 1. A microsco examination proved the fungus to be identical in the two cases, the explanation of its diversity of habit must be sought in the mod infection of the leaf surface. Holding the leaf in the light one see, extending even beyond the fungus in its onward march, a glis ing track ready for its approach. The peculiar gleam and the cha teristic windings are almost proof that it was made by some a crawling over the leaf and leaving a trail of its glutinous secre Sections show the track to be purely superficial, and we are led to clude that this animal, be it worm or snail, has first visited l bearing mature asci and spores or conidia, and then, with its laden with them, has crawled over another leaf in a tortuous freely sowing the spores, which promptly develop. The res white mycelium and conidia plainly mark the track.

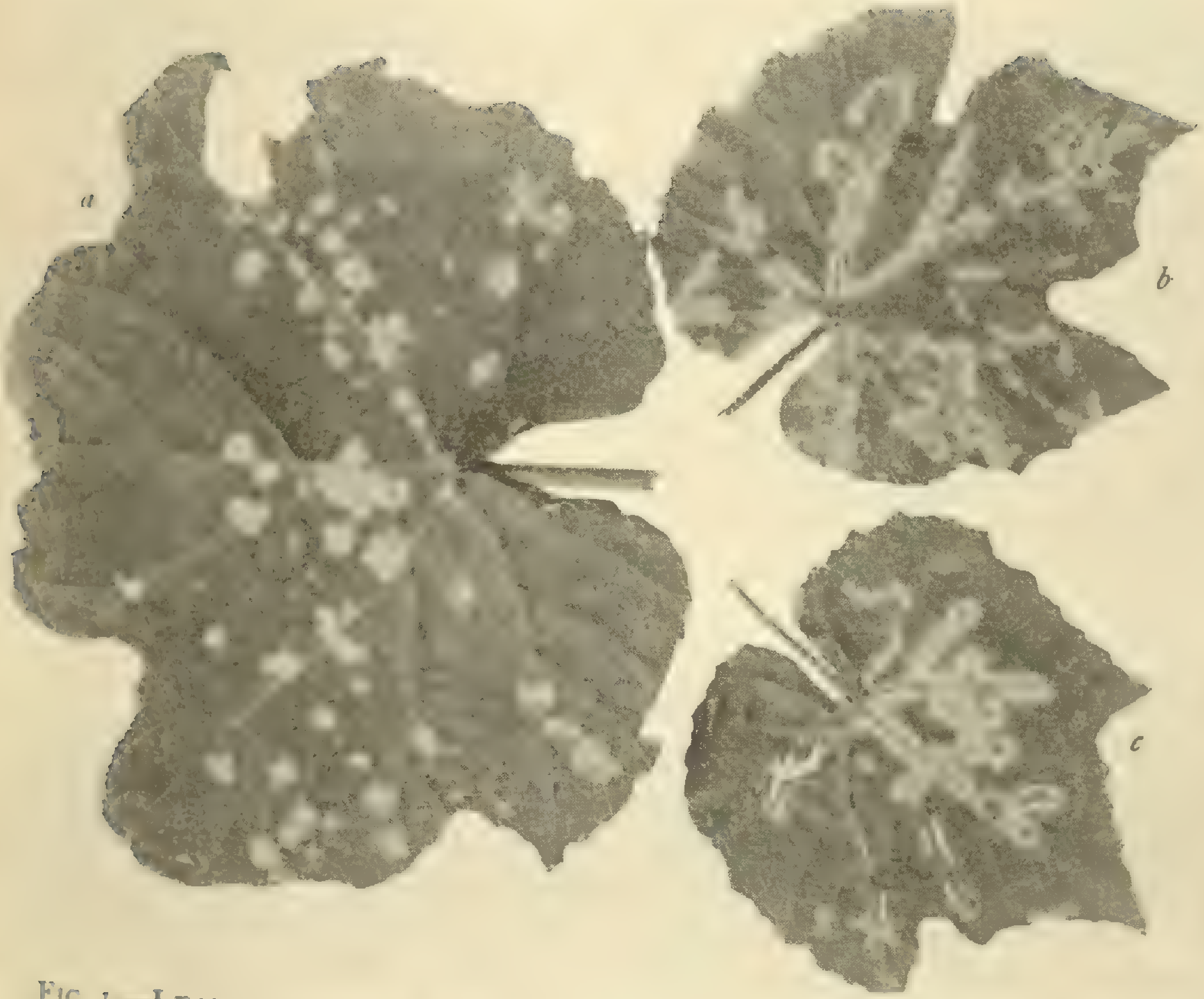

Fig. 1.—Leaves of grape vine; *a* showing usual infection of Uncinula; *b*, *c* showing infection, by crawling animal.

The photograph from which the figures were made was kindly prepared by Mr. M. B. Griffith of Columbus, Ohio.— F. L. Stevens, *The University of Chicago.*

A NEW SILPHIUM.

Silphium lanceolatum, n. sp.—Stems about three feet high, slender, glabrous, striate, bearing a few small partly clasping bracts: leaves all at or near the base of the stem on long and slender petioles, lanceolate in outline, acute at summit, and very tapering at the base, thin but coarse, somewhat undulate toothed or nearly entire, four to eight or more inches long, the edges and midrib beneath somewhat hairy, otherwise smooth: heads few (one to three as far as seen), terminating the long slender branches or main stem, the former of which are bracteate at base and bibracteate an inch or two above: involucres very smooth, the outer scales orbicular, the inner (three or four) oblong and twice as long as the outer, obtuse and thin at summit: achenia broadly obovate, narrowly winged, having a broad and shallow emargination at summit without cusps; rays not seen.

Collected on Chickamauga battlefield, Georgia, October 6, 1898.

The affinity of this plant is with *S. terebinthinaceum*, from which, however, it is very different. It is evidently more nearly allied to Elliott's *S. pinnatifidum*, which I have not seen, but it does not agree with his description.—WM. M. CANBY, *Wilmington, Del.*

OPEN LETTERS.

IMPERFECTIONS OF LABORATORY MATERIAL

THE experimenter must be keenly alive to possible imperfections of the material of which his apparatus is constructed, a fact made apparent by a recent experience in this laboratory with a bleeding-pressure demonstration. The demonstration consisted of a T-tube filled with water, attached to the stump of a plant, and to the short arm an open manometer, filled with mercury. The pressure of the exuding sap set up a difference of level between the columns of mercury in the arms of about 8cm. After this point had been reached the mercury remained stationary and the sap appeared to be passing the mercury in some manner, as it appeared in an increasing amount on top of the mercury in the free arm of the manometer, finally filling it and overflowing at a height of 60cm. This puzzling action was explained by the fact that the manometer tube showed a minute groove throughout its entire length on the inner side of the wall so small that it could not be entered or filled by the mercury. This permitted a constant stream of water to pass by into the other arm of the manometer. Of the many things which may occur to disconcert the beginner in studying root-pressure, the above is doubtless one of the most unusual.—D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

Vines' "Elementary text-book."[1]

This book was prepared to meet a demand for a less bulky and expensive volume than the author's *Students' text-book of botany*. So far as bulk is concerned, the present volume contains about 200 pages less than the former, and simplification has taken the form of omitting certain "difficult and debatable topics, such as the details of nuclear division, and the alternation of generations in the thallophytes."

As before, the book is divided into four parts, Morphology, Anatomy and Histology, Physiology, and Classification. The author lays no special stress upon the sequence of parts, stating that the different parts should be studied together, but he has concluded to let Physiology precede Classification, instead of following it, as in the *Students' text-book*.

The first three parts contain clear and compact statements of the general facts of morphology, anatomy, and physiology, as the author defines these subjects. As morphology is usually studied, however, its most essential facts are placed by the author under "classification." In fact, the morphology, as here presented, is impossible of comprehension without some knowledge of life histories, and of the evolution of organs as presented by different plant groups. The reviewer questions the advantage of presenting morphology to elementary students apart from plant groups.

The part devoted to physiology contains but seventy-six pages, and, of course, is an excellent presentation of what may be called physiology proper, or that phase of physiology which deals with life processes; but it is to be regretted that no mention is made of that phase of physiology which deals with life relations, the phase which we have come to call ecology. This subject has had sufficient development to demand treatment in any elementary text-book, and a few pages given to it could well have been spared from the dreary waste of angiosperm families (occupying nearly 100 pages), which no elementary student uses or can use to advantage.

In the fourth part, the first notable change is the recognition of gymnosperms as an independent group, which is certainly justifiable. Hence, the old group "phanerogams" or "spermatophytes" disappears, being replaced by gymnosperms and angiosperms. In spite of this change, however, general characters of gymnosperms and angiosperms are discussed togeth under the heading "Phanerogamia." On account of the great differen between the groups this composite presentation is very confusing, and ca hardly be justified by the fact that they both produce seeds. It would ha been far less misleading, as well as clearer, had the two groups been ke consistently apart.

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[1] Vines, Sydney H.: An elementary text-book of botany. 8vo. pp. xv + 611. The Macmillan Company: New York. 1898. $2.25.

The thallophytes are treated as before, all of them being either alg fungi; and the treatment of each one of these divisions follows the old ar ficial method, convenient for simple presentation, but very misleading as the facts of genetic relationship. It must be confessed that the treatment thallophytes in this volume and in its predecessor does not represent knowledge of the group. The account of the fungi especially is to be cr cised. In the Filicineæ we note that the author bases his main divisions eusporangy and leptosporangy, rather than upon homospory aad heterosp as in the former volume, a change more in accord with the present con tions of the group.

The classification of angiosperms, however, can hardly be excused on a plea. Why the classification of Bentham and Hooker's *Genera Plantar* was persisted in, in view of all that has been done since to increase knowledge of this group, is something of a mystery. A certain amoun conservatism is wise in a text-book, especially in an elementary one, but th is a difference between conservatism and the perpetuation of a classifica which has been outgrown.—J. M. C.

The flora of Roumania.[2]

BOTANISTS unfamiliar with Roumanian will be restricted to the na of plants in their use of this book. In the presentation of a flora, h ever, plant names represent no small amount of information. Only spermatophytes and pteridophytes are included, and the classification the old type, as the division of dicotyledons into "dialypetalous," "gam alous," and "apetalous" series would indicate. Probably the most star evidence of antiquity, however, is the inclusion of Gnetaceæ and Co among the families of apetalous dicotyledons!

The work is not a descriptive flora, but a list, with full bibliography, g graphical distribution, and critical remarks. Unfortunately, the descri of new species are in the vernacular, instead of Latin. Over one hu pages are devoted to a discussion of the geographical distribution of the of Roumania, which probably is the most interesting and important fea the book.

[2] GRECESCU, DR. D.: Conspectul Florei Romaniei. 8vo. pp. xvi + 830. länder & Sohn: Berlin. 1898. *M* 12.

Certain statistics in reference to the flora are of general interest. The overwhelming preponderance of dicotyledons is shown in the following enumeration: dicotyledons 2109, monocotyledons 447, gymnosperms 11, pteridophytes 35. The largest families are Compositæ (328 spp.), Gramineæ (182), Leguminosæ (146), Caryophyllaceæ (141), Cruciferæ (139), Rosaceæ (124), Labiatæ (109), Umbelliferæ (109). Certain families are conspicuous by their poor representation, as Malvaceæ (11 spp.), Ericaceæ (14), Asclepiadaceæ (3), Polemoniaceæ (1), Acanthaceæ (1), Verbenaceæ (2). The large genera are Carex (55 spp.), Hieracium (38), Centaurea (35), Veronica (31), Ranunculus (29), Dianthus (27), Silene (27), Trifolium (27), and Galium (25). Aster is represented by but four species, and Solidago by one. Festuca is the largest genus of Gramineæ, and Verbascum of Scrophulariaceæ. Aside from the grasses and sedges, the monocotyledons form little more than 6 per cent. of the vascular flora.— J. M. C.

The flora of the West Indies.[3]

UNDER the editorship of Dr. Urban we are promised a valuable work on the flora of the West Indies. This very important region has been in the possession of so many governments that the literature of the flora is badly scattered. It is a great boon to botanists to have it brought together in compact form. The work will be of especial value to American botanists, who are largely interested in the study of the flora of Mexico and the Central American states.

This first part is by Dr. Urban himself, and is a remarkably complete and painstaking bibliography. Not only is the literature of the region presented, but under each title is a synopsis of the contribution, so that one may know just how important a publication each title represents. At the close of the part is a conspectus of the literature by islands and also by plant groups. It would seem as if any published botanical information in reference to any island or plant group can at once be discovered in this remarkable bibliography.

The work will be issued in parts at indefinite intervals, each part containing about 160 pages, and three parts forming a volume. The subscription price will vary from $2 to $3 for each part.— J. M. C.

Nature study.

THE increase of interest in nature study has called forth a large number of publications intended to assist teachers and pupils in this work. Many of these have been little more than compilations of fantastic stories about natural

[3] URBAN, IGNATIUS: Symbolæ Antillanæ seu fundamenta floræ Indiæ occidentalis. Vol. I. Part I. Bibliographia Indiæ occidentalis botanica. 8vo. pp. 192. Fratres Borntraeger: Berolini. 1898. *M* 10.80.

objects, made by persons with excellent imaginations and a little inaccur information upon several scientific subjects. As a result nature study looked upon, in some localities, as a rather frivolous pastime, which is no any very great importance in the real business of education. There are eral books, however, which do not attempt to show that all animate obj are spectacular, but rather attempt to direct attention to the manifestation life in our everyday contact with it. It is to the latter kind of helps that D. Lange's excellent book belongs.[4]

The guiding principle of the book has been that pupils must see examine real objects, not merely their pictures and descriptions. The sons are planned with the idea of having pupils obtain their knowled first-hand so far as possible. Part of the work is arranged with referen seasons, as "Life about our homes in the fall," and "Some forest trees in winter conditions," while other sections deal with particular subjects, "Geological action of water." Lessons about many of the common p birds, and mammals are presented in such an attractive style that even young pupils will doubtless be entertained and instructed by following th The author's aim is primarily to cultivate habits of observation; inciden the pupil will obtain a great deal of valuable information.

The author says that in order to do good work it is not necessary that teacher shall have taken a course in botany, zoology, or geology. It is p ble that much good work may be done by some teachers who have no such opportunities; however, it is beyond doubt that elementary science in primary and secondary schools has suffered very greatly at the han teachers who have attempted to teach science subjects without havin necessary preparation for it. The book under discussion will certain much toward assisting weak teachers, but we insist that nothing short ough instruction in these sciences, added to ability to teach, can teachers fully competent to handle nature study.—O. W. CALDWELL.

A satisfactory work on fertilizers.

THE marked increase in the use of commercial fertilizers in the States has given rise to a demand for reliable information regarding the position and utility of such goods. The official reports of those states have laws regulating the sale of fertilizers give abundant analyses of goods actually on the market, but the limits of such reports prevent discussion of the questions which arise in practice. A great mass of has been written in regard to feeding both plants and soils. Much matter is in the form of special pleading for some particular "system very little of it is recent or applicable to American conditions. The worker and the investigator in field, garden, or greenhouse, felt the need of some reliable work dealing in a plain way with the principles and practice involved in economical plant feeding. Such a work has been supplied by Professor Voorhees,[5] who has the happy faculty of telling what one wants to know, and telling it briefly. One is told what to do and given a reason for doing it, and due consideration is given to modifications required by special or unusual conditions.

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[4] LANGE, D.: Handbook of nature study. For teachers and pupils in ele schools. 12mo. pp. xvi + 329, *figs. 60*. The Macmillan Company: New Y

The description of fertilizing material is up to date, and the formulas recommended for special crops are those that have been profitable in actual use; not the oft-reprinted ones that can be traced back only to advertising matter.

In addition to the specific information in regard to feeding plants, the botanist will doubtless welcome the clear, brief summary of the several broad systems of fertilization that have been proposed and advocated at great length by their authors.

The author is too genial to be accused of being a philosopher; but here and there he drops a remark that sets one to thinking of the broad questions involved in the production of plants, and then speedily leads one to see how the principles discussed can be reasonably and profitably applied.

The book will receive a hearty welcome from both investigator and farmer. —H. A. HUSTON.

MINOR NOTICES.

THE FIRST NUMBER of *Rhodora*, the journal of the New England Botanical Club, has made its appearance. The editorial staff is as follows: B. L. Robinson, editor-in-chief; F. S. Collins, M. L. Fernald, and H. Webster, associate editors; W. P. Rich and E. L. Rand, publication committee. The purpose is tersely stated as follows: "This journal is founded by the New England Botanical Club, with confidence that it will give new stimulus and wider material aid to the study of our local flora. . . . In the selection of subject-matter, special attention will be given to such plants as are newly recognized or imperfectly known within our limits, to the more precise determination of plant ranges, to brief revisions of groups in which specific and varietal limits require further definition, to corrections upon current manuals and local floras, to altitudinal distribution, plant associations, and ecological problems."

The first number contains the following papers: "Rattlesnake plantains of New England," by *M. L. Fernald;* "Saniculas of western Vermont," by

[5] VOORHEES, EDWARD B.—Fertilizers: The source, character, and composition of commercial and manufactured fertilizers; and suggestions as to their use for different crops and conditions. 12mo. pp. xiv + 335. New York: The Macmillan Company. 1898. $1.00.

E. Brainerd; "Notes on algæ," by *F. S. Collins;* "A prolific gentian," by *W. Deane;* "Myosotis collina in New England," by *E. F. Williams;* "A new wild lettuce from Massachusetts," by *B. L. Robinson;* "Notes on some fleshy fungi found near Boston," by *H. Webster;* "Matricaria discoidea in eastern Massachusetts," by *W. H. Manning;* besides shorter miscellaneous notes.

There is need for just such journals, and *Rhodora* is certain to fill its mis- sion. The GAZETTE congratulates the editors upon the appearance of the initial number, and wishes the new venture great success. — J. M. C.

THE FIRST PART of a work on the physiology of plant organization has recently been published by Professor Dr. G. Berthold,[6] of the Universit Göttingen. No criticism of this part is possible, since it is merely a record the observations of the author regarding (1) the anatomy of the Scitamineæ (2) the anatomy and development of certain Compositæ, Umbelliferæ, and Araliaceæ; (3) the annual shoots of *Acer Pseudoplatanus;* (4) the devel ment of some roots and axes of Pandanaceæ and palms; (5) the structu and development of leaves and stems; (6) the red coloration of leaves and stems; (7) the dying of leaves and stems.

The discussion of the observations is promised in the second part which to appear very soon. That may be expected to show reason for the publica tion of what, unexplained, seem like trivial details, proper enough in a no book, but unusual in print. The record shows an enormous amount work, for which we are ready to express gratitude as soon as we know wh it means.—C. R. B.

NOTES FOR STUDENTS.

SOME USEFUL physiological data regarding the rate of growth, flower nutrition, and transpiration of *Nelumbo nucifera* Gærtn. are recorded (in En lish) by Mr. K. Miyabe in Tokyo Botanical Magazine **12**: 85–101, 112- 1898.

AT A MEETING of the botanical section of the Russian Society of Na ralists at Kiew, August 1898, Professor S. Nawaschin spoke upon his observations on fertilization in Fritillaria and Lilium. He has found cellulose membranes on all three cells of the sexual apparatus, which w resorbed before the entrance of the sperm nucleus into the embryo sac. sperm cells, he asserts, enter the embryo sac, one of them penetrating the while the other copulates with the nearer polar nucleus! The latter copulates with the other polar nucleus. The brief abstract (Bot. Cen 62. 1899) does not give further details and Nawaschin's interpretation of

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[6] BERTHOLD, G.—Untersuchungen zur Physiologie der pflanzliche Organ Erster Teil. 8vo., pp. iv + 242, *pl. 1*. Leipzig: Wilhelm Engelmann. M 6.

seems most extraordinary and unlikely action of the second sperm will be awaited with interest.— Since the foregoing was in type, a preliminary paper has been published by Nawaschin[7] in which few other important facts are added. The copulation with the polar nucleus is considered as a sexual act, so that "we have to do here with a sort of polyembryony which issues in the formation of a pair of unequally developed twins, of which one develops into a segmented plant, while the other remains thallus-like and is finally consumed by the former."—C. R. B.

MR. CHARLES E. BROOKS has recently discussed[8] the origin and significance of spines, both in animals and plants. He endeavored to arrive at general conclusions relating to the origin and significance of spinosity. The main part of the paper is devoted to conclusions derived from the study of both living and fossil animals. The observations made on plants are somewhat superficial; the same general conclusions, however, are obtained in both plants and animals. These are that spines, whether prickles, thorns, or horns, represent "a stage of evolution, a degree of differentiation in the organism, a ratio of its adaptability to the environment, a result of selective forces, and a measure of vital power."

After some preliminary discussion on the law of variation, the growth and kinds of spines, the ontogeny of the spinose individual, and the phylogeny of spinose forms, the author classifies the causes of spines under eleven categories. With a few unimportant exceptions the spines of plants are referable to only two of these. The first is the "restraint of environment causing suppression of structures." In desert or arid regions leaves and branches may be suppressed to form spines. A secondary influence may determine the abundance of spinose plants in a region. Herbivorous animals destroy the unarmed species, and an old pasture may thus have the prevailing flora offensive to grazing animals. This does not produce spines, but merely drives out all species except those the animal cannot eat; hence the spines are not formed for protection, but merely assume that office as a result of selection.

The other category is "intrinsic suppression of structures and functions." This includes those prickles of brambles and climbing plants that are not produced by suppression of stipules, leaves, etc. The cause of these cortical eruptions, the author admits, is not clear, but he seems to favor the idea advanced by Bailey that they are connected with the general suppression of the plant body, and that they represent abortive attempts on the part of the plant to recover normal proportions. Prickles may often serve for protection and enable the plant to cling to a support, but this is not the initial cause.

Under categories of interpretation the author offers two generalizations.

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[7] Bull. Acad. Imp. Sci. St. Pétersb. 9: 377–382. 1898.

[8] Am. Jour. Sci. IV. 6: 1–20, 125–136, 249–268, 329–359. 1898.

First, spinosity is a limit to variation. It is shown by the individual and the racial development that organs of various kinds are changed to spines, but spines are never changed to other organs.

Second, spinosity is the paracme of vitality. Spiny plants are "always given to die back," "often prune themselves." Spines are more or less dead structures with special physiological function. The internal or physiological changes take place in the early life of the group, while the external differentiations come about at a later period, and in this spinosity is the limit. "Spines then indicate a fixity of physiological characters together with the consequent inability of the organisms to change due to decreasing vitality." —H. N. WHITFORD.

MR. BERNHARD JACOBI (with the assistance of Professor Dr. Stahl of Jena) has prepared a summary of recent researches on proteid formation in green plants. From the *Biologisches Centralblatt* **18**: 602. 1898, we translate:

"The present state of our knowledge concerning the place and conditions for the formation of proteids in green plants . . . . is as follows:

"The special center for the synthesis of proteids is the foliage leaf.

"In the cells participating directly in proteid formation this process (under otherwise normal conditions of vegetation) may be begun in darkness, since carbohydrates enter into reaction with nitric acid, ammonia or amides to the end. But how far the process mentioned progresses depends on the amount of available carbohydrates.

"If the latter are present in abundance the formation of proteids will take place. If, on the contrary, only small amounts of carbohydrates are available, the process ceases in darkness with the formation of amides. Therefore when an adequate augmentation of the carbohydrates is provided for proteids can be produced.

"The supplying of these carbohydrates may be accomplished either artificially or naturally. In the first case the synthesis of proteids may be accomplished in darkness. By the natural method the carbohydrates could only be augmented to an adequate amount by providing, through the access of light, the conditions for assimilation of carbonic acid. In this case the light cooperates indirectly in the synthesis of proteids, because it provides the carbohydrate by the process of assimilation.

"The special source of energy is furnished by the carbohydrates themselves. However, in many cases light also appears to play a part as a source of energy. Godlewski found that, even in air free of carbonic acid, germinated seedlings were able to form proteids from nitrates and sugar. Detmer thinks that in this case light 'has a special importance as a source of energy' because only small amounts of carbohydrates were available." C. R. B.

A RECENT PAPER by Dr. B. M. Davis[9] is of more than usual interest, as it contains the first description of the process of nuclear division in one of the Rhodophyceæ. The studies were carried on at Naples and at Bonn, and the tetraspore mother-cell of Corallina, one of the lime-encrusted red algæ, was selected. The nuclear figure in metakinesis is especially interesting because of the remarkable differentiation of the kinoplasm into two beautiful centrosphere-like bodies at the poles of the spindle. The centrospheres are very large homogeneous bodies without centrosomes. They arise from accumulations of kinoplasm at the opposite ends of elongated nuclei entering prophase conditions. The spindle fibers develop from these regions of differentiated protoplasm, finally appearing as extensions from the outer surface of the centrospheres. The chromatin is scattered in a very finely divided condition through the nuclear plasm, which is homogeneous in structure and lacks the usual linin network. After the division at the nuclear plate the two sets of split chromosomes are drawn up to the centrospheres, finally lying against their surfaces. Here the chromosomes of each set gradually fuse together into one larger chromatin body. The outline of each centrosphere meanwhile becomes ill-defined, and the structure loses its distinctness as a differentiated region of protoplasm, changing into an irregular dense mass, into the midst of which is drawn the chromatin body. A nuclear membrane then appears around and at a little distance from the chromatin body. The daughter nuclei thus have at first only the large chromatin body. Later the nucleolus appears, at first smaller than the chromatin body but soon growing larger. The chromatin body begins to fragment, which process finally reduces that material to the form of minute granules inside the nucleus and around the single large nucleolus. The centrosphere completely disappears as a differentiated region of the protoplasm, leaving no trace of its former presence. It seems to be the morphological expression of certain activities of the protoplasm concerned with nuclear division. There is no evidence that it is a permanent organ of the cell.—J. M. C.

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[9] Kerntheilung in der Tetraspormutterzelle bei *Corallina officinale* L. var. *mediterranea*. Ber. d. deut. botan. Gesell. **16** : 266. 1898.

NEWS.

Mr. J. G. Baker retired as Curator of the Kew Herbarium on January 12, and was succeeded by Mr. W. B. Hemsley.

The removal of Dr. Carl von Tubeuf from Munich to Berlin has caused the suspension of the *Forstlich-naturwissenschaftliche Zeitschrift*, of which he was editor.

Dr. F. W. C. Areschoug, professor of botany in the University of Lund, has retired, and Assistant Professor S. Berggren has been promoted to the place thus vacated.

Dr. W. C. Sturgis has leave of absence from the Connecticut Experiment Station, and is working in the laboratory of Professor H. Marshall Ward, at Cambridge, England.

On December 16, 1898, Dr. Karl Müller, of Halle, the well-known bryologist and editor of *Die Natur*, celebrated his eightieth birthday. The cable brings news of his death on February ninth.

In a bulletin of the Purdue University Experiment Station Dr. J. C. Arthur calls attention to the possibility of developing a beautiful bedding plant from *Cerastium arvense oblongifolium*, which, even in its wild state, is very attractive.

In recognition of services rendered to the colonial governments as Director of the Royal Gardens at Kew, the Queen has conferred upon Mr. W. T. Thiselton Dyer the Knight Commandership of the Order of St. Michael and St. George (K. C. M. G.).

Mr. Charles A. Keffer, of the Division of Forestry, United States Department of Agriculture, has been appointed Horticulturist in the Agricultural College of New Mexico at Mesilla Park. He will leave Washington for his new work about the last of February.

Father J. H. Wibbe died at his residence in Schenectady, N. Y., January 7, 1899, at the age of 60. He was well known to the older botanists as an enthusiastic collector and student of the local flora; and to those who enjoyed his personal acquaintance as a most genial friend.

The Ohio State Academy of Science held its eighth annual meeting December 29 and 30 at the State University. Botanical papers were read by John H. Schaffner, A. D. Selby, Lumina C. Riddle, H. C. Beardslee, E. L. Fullmer, Edo Claassen, W. A. Kellerman, G. M. Holferty, and E. L. Moseley.

THE PHYSICS GARDEN of the Society of Apothecaries, Chelsea, London, founded by Sir Hans Sloane in 1722, which has of late years been much neglected, is to be rejuvenated and suitably maintained. New offices, lecture rooms, and a physiological laboratory are to be built, a curator and head gardener appointed, and suitable lectureships established.

DR. ROLAND THAXTER, during his visit abroad last spring and summer, obtained specimens of Laboulbeniaceæ at Paris, London, and Oxford, representing material of world wide distribution. These collections will probably double the size of the family. On account of Mr. Thaxter's serious illness, from which he has happily recovered, work upon them has been delayed.

MR. GILBERT H. HICKS, of the Department of Agriculture died suddenly at his home in Washington December 7, 1898. He was First Assistant Botanist and Seed Expert, and was also editor of the *Asa Gray Bulletin*. He was a native of Michigan, and received his government appointment in 1894. Mr. A. J. Pieters, heretofore associated with Mr. Hicks, has succeeded him in charge of the pure seed investigations.

PROFESSOR D. T. MACDOUGAL of the Botanical Department of the University of Minnesota has been appointed Director of the Laboratories of the New York Botanical Garden. He will take up his new duties July 1, at which time the new museum and laboratory building of the Garden will be ready for occupancy. The laboratories in question will be devoted entirely to research work. No students will be received until an adequate laboratory equipment has been secured and put in place, a matter which will occupy the director's attention for a few months. This transfer leaves a vacancy in the assistant professorship of botany at the University of Minnesota. It will probably be filled at the April meeting of the Board of Regents.

THE EXTENSIVE collection of Compositæ of the late Dr. F. W. Klatt of Hamburg, the well-known specialist in this order, has been purchased by the Gray Herbarium of Harvard University. The collection is estimated to contain about 11,000 specimens, together with very numerous and skillfully executed drawings of types. The indefatigable character of Dr. Klatt's work is recognized by all who have been interested in tropical Compositæ. Indeed there are scarcely any medium sized or large genera of the order which have not been enriched by his specific characterizations. Especially numerous are the species of Vernonia, Eupatorium, Verbesina, and Senecio. Of Dr. Klatt's species (except the Costa Rican plants of Pittier) the representation in America has hitherto been very incomplete. The Klatt Herbarium, however, contains not only the Klatt types but numerous authentic specimens of other rare species, and from a conservative estimate, based upon a partial count, it is believed that the collection includes no less than 60 genera and 150 species not hitherto represented in the Gray Herbarium or, for the most part, in American herbaria at all. Before the accession of the Klatt collection, the Compositæ of the Gray Herbarium were estimated at about 35,000 mounted sheets, many of which hold two to five specimens.

THE WASHINGTON BOTANICAL CLUB was organized by a gathering of botanists held at the residence of one of its members November 11, 1898. The limit of membership was fixed at twenty, and it was determined that the meetings, for the present at least, should be of a distinctly social and informal nature, with free opportunity for discussion and the general interchange of ideas. At a subsequent meeting, held December 14, the organization was perfected by the election of Professor Edward L. Greene as President, and Mr. Charles L. Pollard as Secretary. The Club is to hold monthly sessions, devoting itself chiefly to systematic and ecological work, the field of plant physiology and pathology being covered by the already existing Botanical Seminar.

At the December meeting the following resolutions, commemorative of the late Gilbert H. Hicks, were unanimously adopted:

"It is with extreme sorrow and heartfelt regret that we learn of the death of our friend and colleague, Mr. Gilbert H. Hicks. To all of us he was known intimately as an earnest co-worker in the field of science, and a genial member of our social organizations. His energy, earnestness, and conscientiousness in scientific work commanded our approval, and secured recognition for him in all circles as an able investigator. He had already done much to advance knowledge in his chosen line of work, and we feel that the cause of science has lost greatly by his untimely death.

"Much of his work, though of a high scientific character, had been so directed as to yield results of the greatest practical value in the production of food crops, and was intended to lighten in some degree the burden of struggling humanity. As a botanist his keen appreciation of practical problems and his extensive knowledge of plant life well fitted him for this work for the people, and not only science has lost by his death, but all tillers of the soil, those who plow, sow, and reap, have lost a true friend and counselor.

"Yet to us, his daily associates, the loss is greatest. We shall miss his cheery greetings, his companionship, his counsel. It is thus with feelings of deepest sorrow and regret that we have learned that he has been taken from us while yet in the prime and vigor of early manhood. To his sorrowing family we desire to express our heartfelt sympathy and condolence. We realize how inexpressibly great the loss has been to them, and we mourn with them.

"Resolved that a copy of the above resolutions be sent to the family of the deceased, and to the leading botanical magazines in this country."—CHARLES LOUIS POLLARD, *Secretary*.

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Her heart is light,
For she's found .... **Sapolio.**

Vol. XXVII MARCH 1899 No. 3

THE

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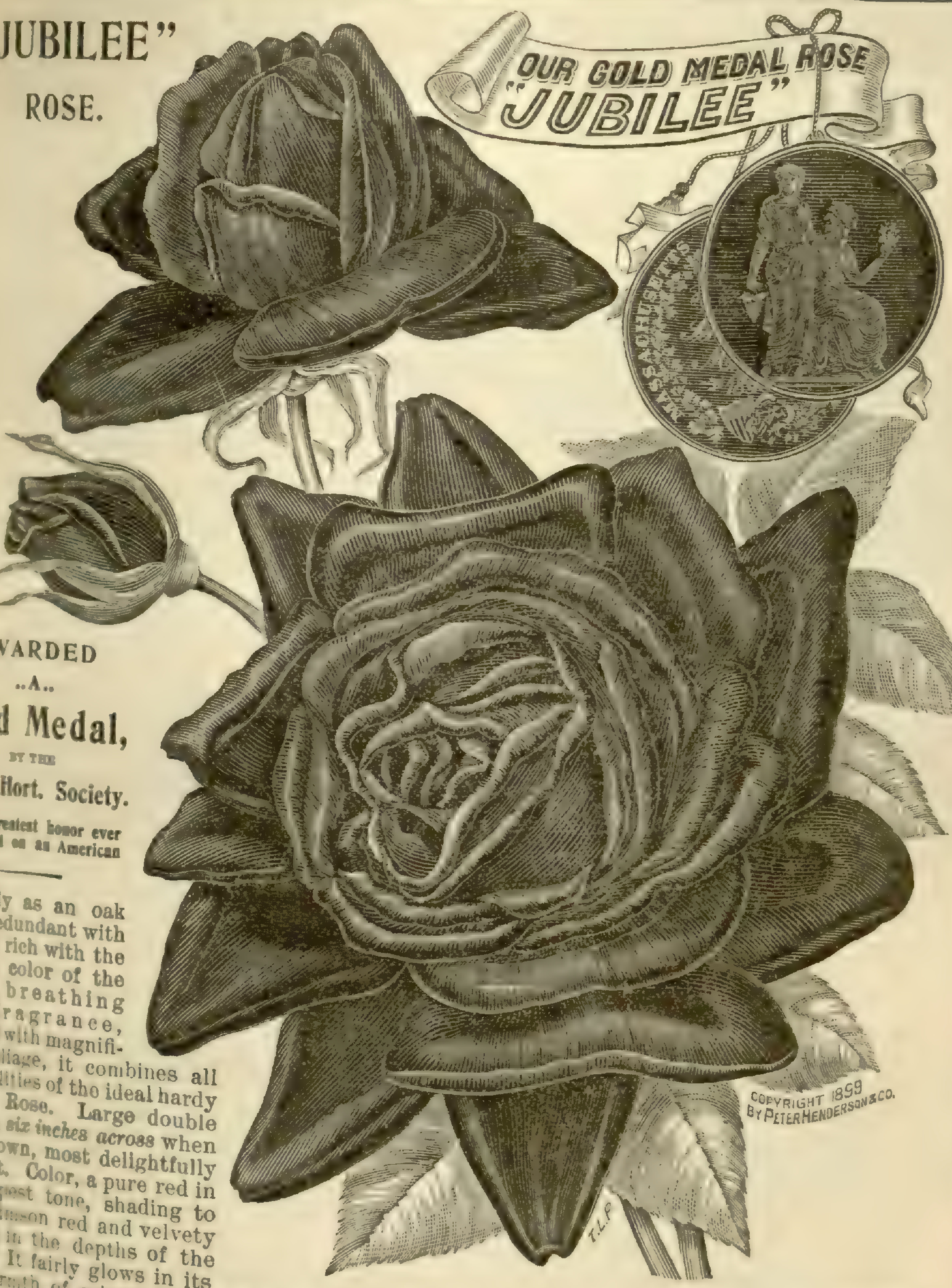

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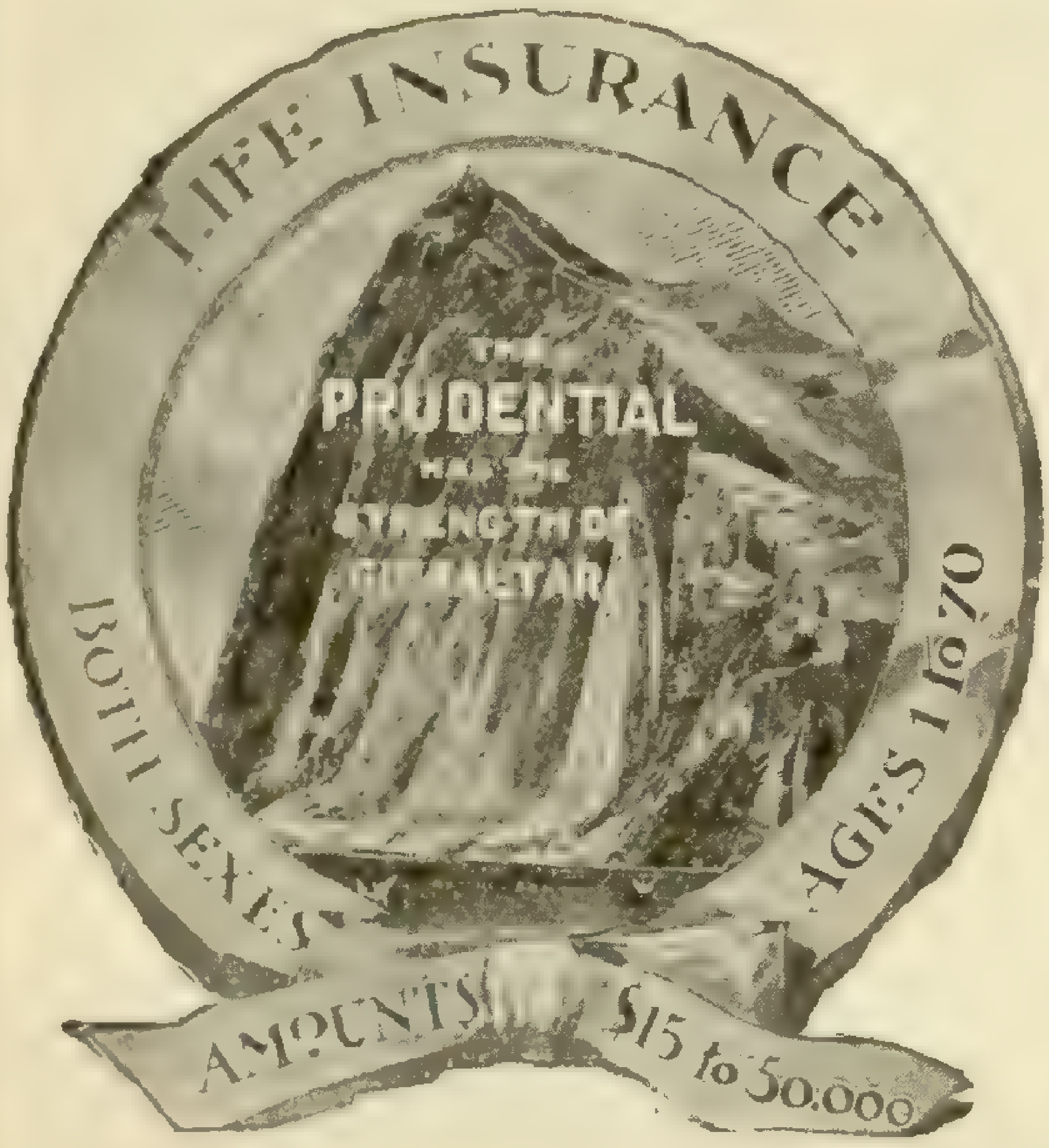

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VOLUME XXVII NUMBER 3

BOTANICAL GAZETTE

MARCH 1899

NOTES ON THE STRUCTURE OF THE EMBRYO-SAC IN SPARGANIUM AND LYSICHITON.

DOUGLAS HOUGHTON CAMPBELL.

(WITH PLATE I)

RECENT studies on the structure of the embryo-sac of the angiosperms have made it very evident that more variation exists than was formerly supposed. All forms as yet examined agree in the essential characters of the earlier stages of the embryo-sac, but its later stages show much variation, especially in the character and behavior of the antipodal cells. Other marked deviations from the type structure have been recorded, but as yet these are too few and fragmentary to be of much value in interpreting the homologies of the structures of the embryo-sac. These discoveries, however, render it important that a careful study be made of the simpler types of angiosperms, as it is becoming more and more evident that it is among these that the primitive types are to be sought, and here, if anywhere, the clues to the origin of the angiosperms are likely to be discovered.

The writer has been for some time engaged upon a study of the simpler monocotyledons in the hope of being able to throw some light upon their affinities, which at present are very far from being clearly understood. Especial attention has been given to the study of the embryo-sac and embryo. Some of the results of these studies have already been published,[1] and the present paper is a record of some of the more striking facts, especially in regard to the antipodal cells, brought to light in more recent investigations. It is hoped that it will soon be possible to give a fuller account of these points, as well as a study of the development of the embryo in the forms under consideration.

There is a growing tendency to regard the simpler monocotyledons, *i. e.*, those having either no floral envelopes, or inconspicuous ones, as the more primitive types, instead of assuming, as was formerly done, that they are degenerate forms descended from petaloideous ancestors. The present view is clearly expressed in the arrangement of the orders of monocotyledons in Engler and Prantl's *Natürliche Pflanzenfamilien.*[2] Engler's conclusions are drawn mainly from a study of the flowers, and as yet but little has been done, at least of late years, in the study of the development of these presumably primitive types.

During the past two years I have made somewhat extensive collections of material for these investigations, but as yet only a small part of the material has been worked over, and the results here given are only preliminary to what is hoped will be much more complete, studies which may perhaps help to clear up some of the questions as to the affinities of the lower angiosperms.

SPARGANIUM.

The genus Sparganium is a small one, probably comprising not more than ten species, mostly inhabitants of northern regions, but with representatives in New Zealand and Australia. Sparganium is usually included with Typha in the order Typhaceæ, but Engler has separated it as the type of a special order, Sparganiaceæ, with the Pandanaceæ as its nearest relatives.

Some years ago, I had occasion to examine the structure the ovule in S. *eurycarpum* Engelm. and was struck with certain peculiarities which it exhibited, some of which were referred to and figured in my paper on Naias and Zannichellia. Most noticeable was the unusual development of the antipodal cells.

---

[1] CAMPBELL, A morphological study of Naias and Zannichellia. Proc. Cal. Academy of Sciences III. Bot. 1: 1–61. 1897.

Development of Lilæa. Annals of Botany 12: 1–28. Mr. 1898.

[2] Die natürlichen Pflanzenfamilien II. 1: 183 ff. 1889.

The study of Sparganium was interrupted for various reasons, but in the meantime material of other species was collected and the subject taken up again. During the past summer a good supply of S. *simplex* Huds. was obtained from Tallac, on Lake Tahoe, and through the kindness of Miss Alice Eastwood, a quantity of the Californian species, S. *Greenii* Morong, collected at Lake Merced near San Francisco, was sent me. I had also a small amount of a Japanese species, S. *longifolium* Turcz., collected by me at Akkeshi on the island of Yezo. Of these, S. *simplex* proved the most satisfactory for study and these preliminary notes refer principally to that species.

All the species of Sparganium are monœcious, the heads of pistillate flowers being at the base of the inflorescence. There are usually three or four of these pistillate heads in S. *simplex.* Each pistillate flower in this species consists of a single carpel, containing a solitary ovule, and surrounded by a number of membranaceous floral leaves. In S. *eurycarpum* and S. *Greenii*, the pistil is composed of two carpels.

In making sections of the carpels for the study of the embryo-sac, except in the youngest stages, care must be taken to remove enough of the hard outer tissues to permit the penetration of the fixing and embedding agents. Of the various fixing agents employed, the best results were obtained from the use of saturated solutions of corrosive sublimate or picric acid in alcohol. The chromic acid mixtures proved less satisfactory. A double stain of Bismarck-brown and anilin-safranin gave the best results.

All of my material was too old to make it possible to study the origin of the ovule and the early history of the embryo-sac. The development of the flowers has been studied by Dietz,[3] and from his figures it looks as if in Sparganium, as in most of

[3] Bibliotheca Botanica 5: —. 1887.

the simpler monocotyledons hitherto investigated, the ovule is axial in origin.

The early history of the embryo-sac could not be traced, but as the mature sac, at the time of fertilization, corresponds closely with that of the typical angiosperms it is not likely that there are any marked peculiarities in its early development.

In the mature ovule (*figs. 1, 2*) the broad apex of the embryo-sac is covered by two layers of cells, the outer ones being elongated so that the apex of the nucellus is pointed. The cytoplasm is confined to an extremely thin layer lining the wall, and a small amount surrounding the polar nuclei. The egg-apparatus is relatively small but offers no especial peculiarities. The synergidæ (*fig. 2, s*) are smaller than the egg (*o*), and their cytoplasm is densely granular, whereas the egg appears almost transparent. The nuclei of the synergidæ are small, but distinct, and like that of the egg, they possess a conspicuous nucleolus. The nucleus of the egg is somewhat larger than the nuclei of the synergidæ, but otherwise resembles them.

On examining the antipodal region of the embryo-sac (*fig. 3*) the very small size of the antipodal cells (*ant*) is at once noticeable; indeed, where these have collapsed in the process of embedding, it is almost impossible to see them at all.

The polar nuclei are much larger than the other nuclei of the embryo-sac, and probably always fuse before fertilization is effected. This, however, has not been positively shown. In the specimen shown in *fig. 3*, the fusion of the polar nuclei was complete, and the single large endosperm-nucleus (*en*) was very conspicuous. In the embryo-sac of *S. Greenii*, however (shown in *fig. 4*), the two polar nuclei were clearly distinguishable, although they were in close contact.

The actual fertilization has not yet been observed, and owing to the small size of the nuclei of the pollen-spore and pollen-tube, it is not likely that this will be easy to demonstrate satisfactorily.

As usual, the synergidæ disappear after fertilization, and the egg-cell, now become the one-celled embryo (*fig. 6, em*), ...

alone be distinguished at the upper end of the embryo-sac. There is little change in the embryo for some time, and it remains undivided until after there is a considerable development of the antipodal cells and endosperm.

An examination of the antipodal region of the recently fertilized embryo-sac (*fig. 7*) reveals a remarkable change in the antipodal cells, which seem to be immediately affected by the act of fertilization. While the embryo-sac itself has not increased appreciably in size, the antipodal cells have now enlarged to several times their original dimensions and present all the appearances of actively growing cells. The nuclei have divided, and in the specimen figured there were already present eight antipodal nuclei. It was difficult to decide whether in all cases the division of the nucleus was accompanied by the formation of a division wall, or whether, as in some other cases of multiplication of the antipodal nuclei, the division of the nucleus occurs without the formation of a cell wall.

The first division of the endosperm-nucleus takes place at about the same time that the first nuclear-division occurs in the antipodal cells. The secondary endosperm-nuclei arrange themselves, in the usual way, in the thin layer of protoplasm lining the wall of the embryo-sac, which now rapidly increases in size. Before any cell-division takes place in the endosperm, the antipodal cells have increased enormously in size, and have divided until they form a conspicuous hemispherical cell-mass projecting into the large lumen of the embryo-sac (*fig. 8*). The number is very great, more than a hundred, or in some older stages a hundred and fifty, thus exceeding, so far as I know, those of any other plants yet investigated. Each cell is clearly defined and is plainly uninucleate. The cytoplasm is very finely granular. The antipodals at this stage recall strongly those of certain Gramineæ.[4] It is very clear that we have to do here, not with a rudimentary structure, but with one which is undoubtedly of physiological importance. The endosperm at this stage is scarcely at all developed, and here also, as Westermaier has pointed out in Zea and other grasses, this group of antipodal cells functions as the endosperm in the early stages of development after fertilization.

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[4] WESTERMAIER, Zur Embryologie der Phanerogamen, etc. Nova Acta d. kaiserl. Leop. Carol. Akad. der Naturf. **57**: 1–30. 1890.

The nuclei in the antipodal cells of Sparganium never show any indications of fragmentation, such as has been described for the large antipodal cells of some Ranunculaceæ,[5] but they remain sharply defined, and the large nucleolus persists unchanged so far as has yet been observed.

Later there is the usual formation of cell-walls between the endosperm-nuclei, and the development of the endosperm proceeds centripetally. In the oldest stages examined (*fig. 9*), the large mass of antipodals was still evident, although there were some indications of breaking down in these cells. Whether traces of them can be detected in the ripe seed remains to be seen.

The development of the embryo of Sparganium has been already followed in *S. ramosum* Huds. by Hegelmaier,[6] but he gives no account of the embryo-sac. My own studies on the embryo are still too incomplete to make a comparison with the results of Hegelmaier possible. The embryo has the suspensor only slightly developed and there are a number of suggestive resemblances to the embryo of the grasses, which, in connection with the strong similarity in the embryo-sac, point to a possible connection between the Sparganiaceæ and Gramineæ.

As already indicated, it is among the Gramineæ that we find the type of embryo-sac which resembles most that of Sparganium. Hofmeister[7] was the first to call attention to the conspicuous antipodal cells in certain Gramineæ, and showed that the number might exceed the three usually found in angiosperms. Among the Triticeæ he found the number to be from six to twelve.

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[5] MOTTIER, Contributions to the embryology of Ranunculaceæ. BOT. GAZ. 20:241, 248, 276, 304. 1895.

[6] Zur Entwickelungsgeschichte monocotyledoner Keime. Bot. Zeit. 32:631. 1874.

[7] Embryobildung der Phanerogamen, II. Monocotyledonen. Abhandl. d. königl. sächs. Gesell. d. Wiss. 7:—. 1861.

The later work of Westermaier,[8] Fischer[9] and Koernicke,[10] has confirmed the results of Hofmeister's investigations and added a good deal to them. Of these investigators, Koernicke alone gives definite information as to the number of antipodal cells which may occur. According to his statements, the number may rise to thirty-six or even more, the largest number, so far as I know, yet recorded, but, as we have seen, very much smaller than the normal number in the older embryo-sac of *Sparganium simplex*. The most noticeable difference, aside from the number of the antipodal cells, is the very inconspicuous character of these before fertilization in Sparganium when compared with the antipodal cells of the Gramineæ.

LYSICHITON.

Lysichiton Kamtschatcense (L.) Schott is a monotypic aroid of northeastern Asia and Pacific North America where it extends from Alaska to northern California. In general appearance it is much like the eastern skunk-cabbage, and it is locally known by the same name. Its inflorescence, however, is quite different and recalls that of some species of Anthurium; indeed, the whole plant resembles some of the larger species of this tropical American genus.

I am indebted to Professor Hill of the University of Washington for material of the young flowers and fruit, which he kindly sent me from Seattle. Material of the older stages was collected by me in the neighborhood of Sitka, where the plant grows in great abundance.

The Araceæ have been somewhat neglected in the numerous embryological studies that have been made upon the angiosperms, and, aside from Hofmeister's researches, there is very little work upon the development of the embryo-sac. Fischer[11] gives some account of the development of the ovule and embryo-sac in Arum, and Mottier has investigated the same points in Arisæma,[12] but beyond these I have not been able to find any references to the embryo-sac in this very characteristic group of plants. As the work of Hofmeister had already shown that the Araceæ exhibit certain marked peculiarities of the embryo-sac, it is remarkable that these plants have been overlooked in the more recent studies of the embryo-sac. The Araceæ give many indications of being a primitive and generalized order, and no group of angiosperms is likely to furnish more important data as to the origin of the structures of the embryo-sac.

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[8] WESTERMAIER, *loc. cit.*

[9] FISCHER, A., Zur Kenntniss d. Embryosacentwickelung einiger Angiospermen. Jenaische Zeitschrift **14**:—. 1880.

[10] KOERNICKE, Verhandl. d. naturhistor. Vereins d. Preuss. Rheinlande, etc. **53**: 149. 1896.

[11] FISCHER, *loc. cit.*

In addition to the study of Lysichiton, the more important results of which are here given, more or less extensive studies have been made upon a number of tropical aroids, but these are not yet completed. The forms examined included species of Anthurium, Philodendron, and Dieffenbachia, collected in Jamaica during the summer of 1897.

The ovule of Lysichiton is very large (*fig. 10*) and characterized by the massive basal part, which is extraordinarily large when compared with the nucellus. In the younger ovule the outer integument is only slightly developed, but later it grows out beyond the inner one (*fig. 15*). The embryo-sac is deep-seated. So far as its early development has been followed it does not differ from that of the typical angiosperms, and there are found the usual structures of the mature embryo-sac, *i. e.*, the egg-apparatus, polar nuclei, and three antipodal cells. While the embryo-sac itself is decidedly smaller than in Sparganium the egg-apparatus and antipodals are much larger.

At first the nuclei of the cells of the egg-apparatus and the antipodal cells are much alike (*fig. 11*), but at the time of fertilization (*figs. 12, 14*) the antipodal nuclei have increased remarkably in size, while there has been little change in those of the egg-apparatus, although both the egg-cell and synergids have increased in volume. As in Sparganium, the latter are much more granular than the egg-cell, but there is less difference in size than is the case in Sparganium.

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[12] MOTTIER, On the development of the embryo-sac in Arisæma triphyllum. BOT. GAZ. 17: 258. 1892.

In the specimen which is shown in *fig. 14*, which was probably ready for fertilization, the two polar nuclei were still separate, but whether they fuse before fertilization is effected must remain for the present undecided.

The subsequent history of the embryo-sac in Lysichiton differs strikingly from that of Sparganium. There is a formation of free nuclei resulting from the division of the primary endo sperm-nucleus, but this is early followed by the formation of division-walls which extend entirely across the lumen of the embryo-sac, and this soon becomes completely filled with the large-celled endospermal tissue (*figs. 15, 16*). This filling of the embryo-sac with a continuous tissue seems to be characteristic of most of the aroids hitherto examined, and recalls the structure of the prothallial tissue in Selaginella or Isoëtes. The same type of endosperm has also been observed in various dicotyledons.

In Lysichiton, as in Sparganium, there is a marked growth of the antipodal cells subsequent to fertilization. They enlarge rapidly and divide, but the number is never large (the specimen figured showed eight). The cytoplasm of the antipodal cells is finely granular, and they are doubtless of physiological importance. Sometimes, as in the case figured (*fig. 17*), the antipodals are clearly separated from the basal endosperm cells which are much smaller; but this is not always the case.

The nuclei of the older antipodal cells become very large, and the conspicuous nucleolus of the younger nucleus becomes much less evident. The actual division of these nuclei was not seen, but the appearance of the chromatin in the cells shown in *figs. 12* and *13* indicates that they are preparing for division. The nuclei finally reach an extraordinarily large size, and far exceed those of the endosperm-cells. They are probably finally disorganized, but their further history was not followed. Whether fragmentation occurs, as in the large multinucleate antipodal cells of some

Ranunculaceæ[13] is doubtful, but there is little question that the early divisions are karyokinetic, and each division is followed by the formation of a division-wall.

The upper endosperm cells are usually decidedly larger than those which are in contact with the antipodal cells, but otherwise there is no marked difference between them.

As in the other aroids that have been studied, the upper part of the nucellus persists as a sort of cap covering the apex of the embryo-sac; the lateral tissue of the nucellus, however, is completely disorganized, so that the embryo-sac comes in close contact with the inner integument (*figs. 15, 18*).

So far as my observations go, the species of Philodendron, Anthurium, and Dieffenbachia examined agree closely with Lysichiton in the development of the embryo-sac, but as yet the presence of such conspicuous antipodal cells has not been observed. In many cases noted (see *fig. 18*) the embryo-sac, at a very early period, becomes completely filled with large-celled parenchyma, in which it is impossible to recognize any antipodal cells, nor in many cases can any certain traces of an embryo be detected. It is hoped that a more thorough study of these puzzling forms, which I expect to make soon, will explain the meaning of these appearances.

Except in Pistia, which has been carefully studied by Hegelmaier,[14] I have been unable to find any complete account of the development of the embryo among the Araceæ. Hofmeister gives figures of a few stages of a number of genera, but these are too incomplete to be of much value. A preliminary examination of the embryo of Lysichiton indicates that it is of much the same type as that of Pistia. Probably no suspensor is developed, and the young embryo is very soon completely imbedded in the endosperm, recalling the appearance of the embryo in Isoëtes (*fig. 16*).

The embryo finally completely fills the ripe seed, as it does in many other genera, *e. g.*, Anthurium, but in some of the aroids,

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[13] MOTTIER, *loc. cit.*

[14] HEGELMAIER, *loc. cit.*

e.g., Philodendron, the embryo is smaller and surrounded by abundant endosperm.

SUMMARY AND CONCLUSIONS.

In both Sparganium and Lysichiton there is a normal multiplication of the original three antipodal cells, although the type of these cells is quite different in the two genera. In Sparganium, at least in *S. simplex*, the number of antipodal cells becomes very great, in extreme cases 150 or more, thus far exceeding that of any other known plant. The nearest approach to this is found in certain Gramineæ, where the form of the antipodal cells may be also much like those of Sparganium.

This extraordinary development of the antipodal cells in Sparganium, however, is secondary, and dependent apparently upon the fertilization of the egg-cell. In the unfertilized embryo-sac, the antipodals are unusually small and inconspicuous, and of the usual number. There is no evidence that the nuclei of the antipodal cells divide otherwise than by karyokinesis.

In Lysichiton the antipodal cells probably never exceed ten, but they become extremely large and the nuclei reach enormous proportions. Here, also, no direct division of the nucleus could be detected, but indications of degeneration were observed in the older nuclei, and it is possible that there may be, finally, a fragmentation like that found in the multinucleate antipodal cells of other plants. The character of the antipodal cells in Lysichiton is quite different from those of Sparganium, and, indeed, from those of any other described angiosperms. They resemble most, perhaps, such Compositæ as Senecio and Aster, in which there have been described numerous antipodal cells and a continuous endosperm. In these composites there may be also a multiplication of the nuclei of the individual antipodal cells.

It is evident that we can no longer regard the antipodal cells as merely vestiges of the primitive prothallial tissue. It is true that they probably represent this tissue, but that they may still be of importance physiologically is amply shown both by their great development in the types under consideration, and by researches bearing upon their relation to the nutrition of the structures in the embryo-sac.[15]

Whether the striking resemblances in structure between the antipodal cells of Sparganium and those of certain grasses indicate any direct relationship between the Sparganiaceæ and Gramineæ, remains to be seen; but in connection with the undoubted similarities in the structure of the embryo, it is by no means improbable that these two supposedly isolated orders of the monocotyledons may really prove to be related.

That two such widely separated orders as Araceæ and Compositæ should show analogies in those structures which may very properly be assumed to be of importance as indicating relationships, seems very surprising. It must be remembered, however, that the Compositæ seem to have retained a very primitive type of ovule, *i. e.*, the solitary terminal ovule such as appears to be the most primitive type known in the angiosperms. The same type also occurs in many aroids, and is found again in the simpler Centrospermæ among the dicotyledons, *e. g.*, Polygonaceæ. In the Piperineæ, which show a number of curious analogies with the Araceæ, the same solitary axial ovule occurs. It is not impossible that a further study of Piperineæ may show that in them we have a point of contact between monocotyledons and dicotyledons. If it should be shown that the single ovule of the Compositæ is a primitive rather than a secondary condition, the occurrence of what seems to be a primitive type of embryo-sac in these most specialized of all angiosperms would be comprehensible.

Of course with our present very meager knowledge both of the simpler types of dicotyledons and of the aroids, any positive assertions as to the possible relationships of these groups are out of the question. That these groups deserve more careful study than has yet been given them, admits of little question.

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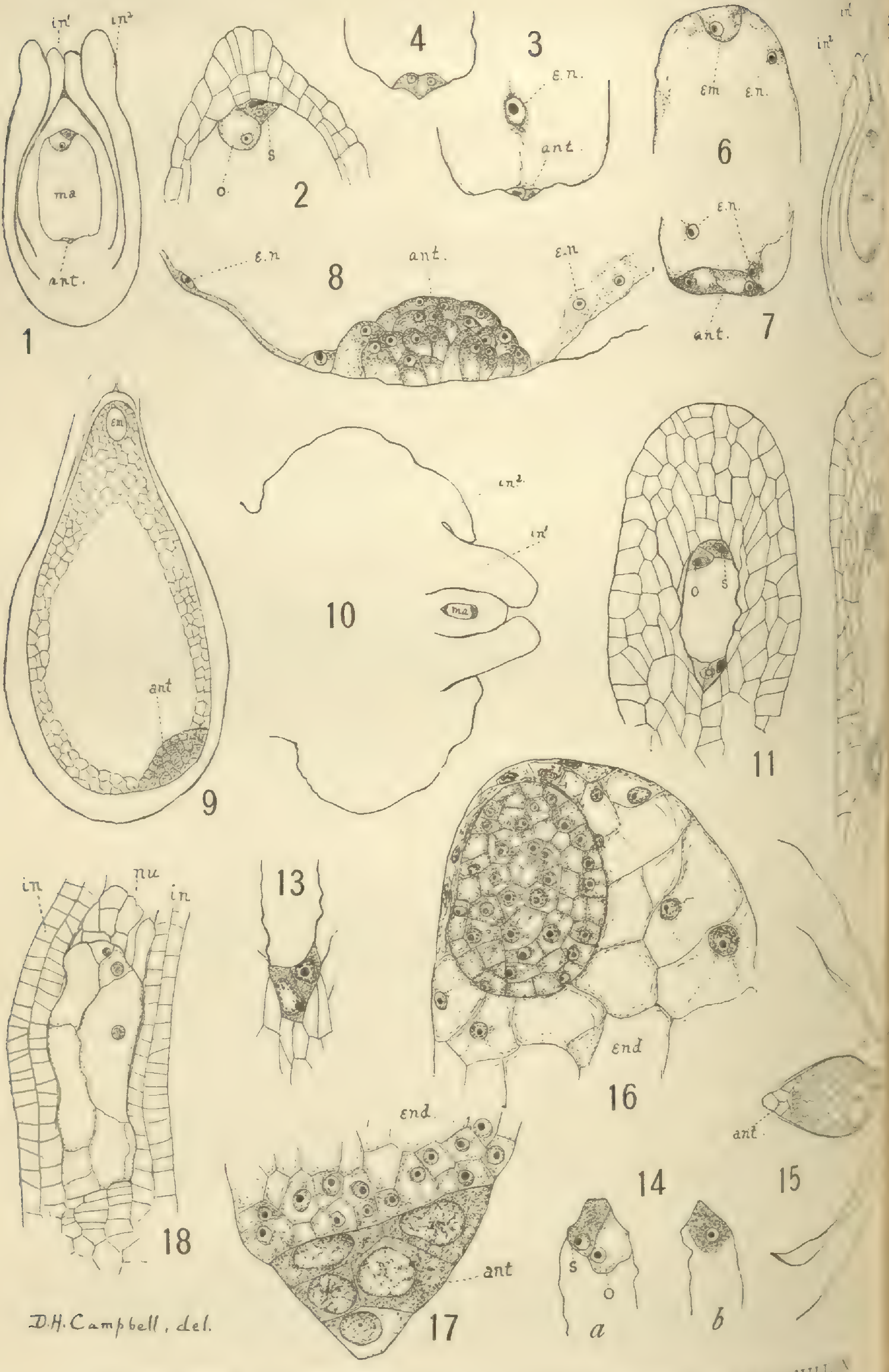
[15] See especially Westermaier's paper already referred to.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D.H.Campbell, del.

CAMPBELL on EMBRYO-SAC of SPARGANIUM and LYSICHI

EXPLANATION OF PLATE I.

All of the figures were drawn with a Zeiss camera—*Figs. 1, 5*, Leitz; obj. 3, oc. 3; *figs. 9, 10, 15;* Leitz obj. 13, oc. 1; the other figures, Leitz obj. 7, oc. 1. *Figs. 1–3, 5–9*, refer to *Sparganium simplex*; *fig. 4*, to *S. Greenii; figs. 10–17*, to *Lysichiton Kamtschatcense; fig. 18*, to *Anthurium cordifolium* Kth.

FIG. 1. Section through the mature ovule of *Sparganium simplex*; in^1, in^2, the integuments; *ma*, the embryo-sac.

FIG. 2. Upper part of the nucellus and embryo-sac, showing the egg-apparatus; *o*, the egg; *s*, one of the synergidæ.

FIG. 3. Basal part of the embryo-sac shown in *fig. 2; ant*, antipodal cells; *en*, endosperm nucleus.

FIG. 4. Antipodal cells of *S. Greenii.*

FIG. 5. Longitudinal section of a recently fertilized ovule; the section is cut at right angles to the one in *fig. 1*, so that the funiculus, *fun*, is shown.

FIG. 6. Upper part of embryo-sac, with one-celled embryo, *em*, and one of the secondary endosperm-nuclei, *en.*

FIG. 7. Antipodal region of the same embryo-sac showing two of the enlarged antipodals and two endosperm-nuclei, *en.*

FIG. 8. Antipodal region of an older embryo-sac, showing the large mass of antipodal cells, and the thin parietal layer of protoplasm with the included endosperm nuclei.

FIG. 9. Longitudinal section of an older ovule, showing the embryo-sac lined with a layer of endosperm, in the upper part of which is embedded the embryo, *em.*

FIG. 10. Longitudinal section of a young ovule of Lysichiton.

FIG. 11. The nucellus of the same more highly magnified. The egg, *o*, and one of the synergidæ, *s*, show at the apex, and two antipodals at the base of the embryo-sac.

FIG. 12. Longitudinal section of a nearly mature nucellus; one antipodal cell only can be seen.

FIG. 13. The two other antipodal cells from the embryo-sac shown in *fig. 12.*

FIG. 14. Two sections through the apex of a mature embryo-sac of Lysichiton; in *a* the egg and one synergid show, the second synergid shown in *b.*

FIG. 15. Longitudinal section of an older ovule with the embryo, *em*, surrounded by a mass of endosperm; the embryo-sac has destroyed all of the nucellus except its apex, *nu; ant*, the antipodals.

FIG. 16. Upper part of an embryo-sac and embryo, of the same age as the one shown in *fig. 15*.

FIG. 17. The antipodal region of the same embryo-sac, showing the marked difference between the antipodal (*ant*) and endospermal (*en*) cells.

FIG. 18. Longitudinal section of the embryo-sac of *Anthurium cordifolium; nu*, the remains of the nucellus; in the inner integument neither antipodal cells nor embryo can be distinguished.

THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

HENRY CHANDLER COWLES.

[*Continued from p. 117.*]

3. The upper beach.

In the strictest sense the upper beach is not a portion of the beach at all, since it is beyond the reach of the waves; it might perhaps be called a fossil beach, but the fact that it is continuous with the beach proper seems to exclude that term, as does the recency of its fossilization. The expression fossil beach will be reserved for a formation of greater geological age and separated from the present beach by other topographic forms. Where dunes are superposed upon the beach, the upper limits of this third beach zone are quite vague, though the theoretical line of demarcation is where the sand is first accumulated by the wind. Where clay bluffs are present at the water's edge, the beach is quite narrow and the upper limit fairly well defined, though at times obscured by alluvial fans. Occasionally the upper beach approaches very close to the water's edge; this is the case where the lower and middle beaches are very narrow because of a high gradient. Sometimes the lower or middle beach zone is replaced by a tiny cliff; in such a case the upper beach may approach to the edge of this cliff. The limits of the upper beach, as of other beach zones, are constantly shifting. The lower limits are carried lakeward or landward by the waves of winter storms, but on the whole the lower limits are pushed out more and more lakeward, keeping pace with the advance of the lower beach. The shifting of the wind causes variations in the upper limits. but on the whole the dunes likewise are commonly formed more and more lakeward, as will be shown further on. The three beaches, then, shift from year to year with apparent irregularity, but there appears to be as a resultant a general progressive movement of them all out into the lake. As a whole the three beach zones slope gradually and somewhat evenly upward, toward the dunes or bluffs beyond; depressions, however, are not at all uncommon, and at times they reach down to the water level, so that a beach pool results.

The life conditions are much less severe than on the middle beach, and chiefly because of the freedom from the wave action of the winter storms. The exposure to the sun is almost as great as on the lower zones, but there is more protection from the wind because of the abundance of driftwood. The protective influence exerted by piles of débris is finely shown on the beach at North Manitou island. The upper beach along the south shore of the lake is usually very sandy and comparatively free from driftwood, while the North Manitou beaches are composed chiefly of gravel and shingle with heaps of driftwood piled about in the greatest confusion. The North Manitou flora is one of marked luxuriance, compared with the more southern type, and many mesophytic species are able to get a foothold in the more genial conditions there obtaining. The decay of the driftwood may also add no inconsiderable portion to the food materials of the beach plants.

The flora of the upper beach is much richer than that of the middle beach, both in species and in individuals, but here as there the vegetation is so sparse that the tone to the landscape is given by the soil. In the region as a whole the most characteristic species of the upper beach are *Artemisia caudata* and *A. Canadensis.*[1]

At nearly all places visited between Chicago and Beaver island Artemisia was present and commonly in abundance. Another plant associated almost everywhere with Artemisia is *Cnicus Pitcheri;* this thistle is seldom so common as Artemisia, but scattered specimens are pretty sure to be discovered on any upper beach. A species scarcely less important in this connection is the beach pea, *Lathyrus maritimus*, another marine plant; locally the beach pea is often the dominant character plant, especially northward. Three other species are character plants over wide areas, as the above three are throughout. *Euphorbia polygonifolia* is a character plant at many stations between Chicago and Glen Haven; its absolute abundance is often as marked on the upper as on the middle beach, though its relative importance is much greater on the latter. *Agropyrum dasystachyum* and *Œnothera biennis* are as characteristic of upper beaches northward as Euphorbia is southward; Agropyrum especially is usually a dominant character plant north of Glen Haven.

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[1] Typical forms of both Artemisias have been found, as well as all interme gradations, and it is all but hopeless to try to determine which is the more abun without careful examination of all the plants in time of fruit. Both species are p cent in beach and dune habitats, although *A. Canadensis* is the more so.

None of the above six species are confined to the upper beach. Artemisia is found in most dune societies inland, especially in comparatively naked places. Cnicus is frequent on the dune complex, though less abundant than on the beach, as is also true of Artemisia. Lathyrus appears to be more restricted in its habitat, and in that sense is more typical of the upper beach, though it sometimes occurs on clay bluffs. Euphorbia occurs on the middle beach and also on naked dunes, though less frequently. Agropyrum, though characteristic of northern upper beaches, is still more characteristic of the embryonic dunes. Œnothera occurs on oak dunes and commonly also as a mesophyte.

At this point it will be well to emphasize one of the fundamental principles of ecological plant groupings. It is comparatively seldom that any single species can be regarded as perfectly characteristic of a formation, while a group of five or ten species can be so selected as to enable one to detect that formation almost anywhere within a large area. No one of the above six species can be regarded as perfectly typical of the upper beach, although Lathyrus approaches such a type, but together they form an assemblage that cannot be found in any other formation, except perhaps locally on the closely related beach dunes. Even on these beach dunes, which grade into the upper beach, the relative proportions existing between the above species are very different from those found on the beach, and, as will be shown later, plant species occur on these dunes which are absent from the beach altogether.

Of the six chief character species of the upper beach, three (Œnothera, Artemisia, Cnicus) are commonly biennials, Euphorbia is an annual, while Lathyrus and Agropyrum are perennials with decidedly social habits through extensive rhizome propagation. Thus the perennial habit is much less common on the upper beach than on the dunes. The three biennials pass through the winter in the form of ground rosettes, tall shoots being sent up in the spring. Cnicus has a noteworthy protective covering of woolly hairs.

There are several plant species very characteristic of the embryonic dunes on the beach, which also occur on the upper beach proper, though rarely in great abundance. Notable among these plants are *Ammophila arundinacea*, and *Elymus Canadensis*. Ammophila occurs about equally throughout, while Elymus is much more characteristic northward; indeed on the northern upper beaches Elymus is sometimes as abundant as Agropyrum or Artemisia. About Chicago Elymus is a common character plant of the dunes, but rarely of the beach. Between Chicago and Muskegon *Asclepias Cornuti* is a frequent tenant of the upper beach. *Calamagrostis longifolia*, one of the chief character plants of the active dunes, is sometimes found on the beach, as are *Solidago humilis Gillmani* (plants large, but leaves not sharply toothed) and *Lithospermum hirtum*, which are more characteristic of rejuvenated dunes, fossil beaches, and heaths. *Cakile Americana* and *Corispermum hyssopifolium* occur but are less abundant than on the middle beach, although the latter is sometimes a prominent upper beach type. The forms discussed in this paragraph are perennials, with the exception of the last two; as they are all of secondary importance, in reality representing the vanguards of a flora which is more at home farther inland, there seems no necessity for any further defense of the idea that the upper beach flora is not typically composed of perennials.

All of the species discussed up to this time are herbs, passing the winter near the surface of the soil or underneath it. The exposure to which shrubs and trees are subjected during the winter is so severe on the upper beach that few of the many dune species have representatives there. The individual shrubs which brave these conditions are relatively scattered, while the plant body is stunted and bears signs of the severe environment provided by the beach. Much the commonest shrub, and the only one which occurs throughout, is *Prunus pumila*, the sand cherry. Poplars occasionally occur, *Populus monilifera* southward and *Populus balsamifera* (both the type and var. *candicans*) northward; so too, the willows, *Salix glaucophylla*, *adenophylla*, and *longifolia*.

The most striking feature of the plant life on the upper beach is the difference in its development at different localities. The luxuriant flora of the north is in marked contrast to the impoverished flora at the south end of the lake. The Dune Park beach, for example, is tenanted only by Artemisia, Cnicus, Corispermum, and a few scattering plants of other species. An upper beach on North Manitou island showed a great abundance of Elymus, Artemisia, Lathyrus, Œnothera, and *Populus balsamifera*, together with thirty-four other species which were rare to frequent. Among these other species several are of considerable interest: *Anemone multifida*, which also occurs on the beach at Beaver island and on several fossil beaches; *Prenanthes alba*, common in woods and thickets but seemingly out of place on the beach; *Equisetum hyemale*, which grows almost anywhere. On similar beaches at Empire, *Achillea Millefolium* and *Equisetum arvense*, two plants which never grow on the beach farther south, are very abundant. *Arabis lyrata* and *Polygonum ramosissimum* (?)[2], the former growing on the inland oak dunes about Chicago, occur on an exposed upper beach at the north end of Beaver island. The reasons for this great luxuriance of the northern upper beaches are not obvious. It has been previously stated that the greater abundance of driftwood on the more northern beaches may furnish considerable protection. This cause seems hardly adequate to account for the great differences, and it may be that climatic or other less apparent factors may have to be called upon. The luxuriance of the northern forests as compared with those about Chicago may need in part a similar explanation.

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[2] A remarkable dwarf Polygonum with six stamens, very different from the type.

Interesting beach conditions are to be found on some small islands that have recently formed on reefs in the vicinity of Beaver island. During the winter and spring blocks of ice laden with stones are stranded on these reefs; thus they are gradually built up to the lake level. Wave action comminutes the reef materials forming a soil suitable for plant life; the waves and winds also constantly add to the area of the islands. One such island is about 200 meters in length, five or ten meters in width, and scarcely thirty centimeters high. The flora of this unprotected island is a swamp flora, *i. e.*, the island is in its entirety a hydrophytic beach. Another island, somewhat larger and considerably older, has an altitude of one or two meters at its highest point. The beach toward the southeast, east, and northeast is hydrophytic, while that toward the northwest, west, and southwest is xerophytic. Undoubtedly the degree of exposure to the wind is the chief cause which determines the nature of the flora on this island. Not only is the wind more severe on the west beach, but the waves pile up more sand on that side of the island and hence produce a drier soil. The flora on this xerophytic upper beach is remarkably complete and diversified, showing a distinct zonal distribution. Above the middle beach there is a zone characterized by the dominance of *Elymus Canadensis*, then a zone of *Geranium Robertianum*, then a zone of *Artemisia Canadensis*, and finally a zone in which *Cornus stolonifera* (or *C. Baileyi* into which it grades) is the chief character plant. Scattered more or less with these are *Prunus pumila*, *Œnothera biennis*, *Lathyrus maritimus*, *Cnicus Pitcheri*, *Agropyrum dasystachyum*, and *Populus balsamifera*. *Pastinaca sativa* and *Geranium Robertianum* are common here, and are remarkable inhabitants of a xerophytic beach, since both are usually inland mesophytes. Two other plants occur on this beach that are south of their chief range and rare in the Lake Michigan region, *Tanacetum Huronense* and

Anemone multifida. The flora of this isolated island beach is remarkably prolific; scarcely a single upper beach type is absent. It is obvious that the means of plant dispersal are so uniformly successful, that almost an entire flora may be transported to a newly formed island within a few years.

One other common feature of upper beaches should be mentioned. As noted above, there are irregularities in the slope of the beach often resulting in depressions which reach below the water level. Such depressions may be called beach pools and of course have a hydrophytic flora; this flora, however, is not the flora of a hydrophytic beach. Beach pools are relatively protected from the action of winds and waves; the chief difference from a hydrophytic beach is that the latter is washed by the fresh waters of the lake, while the beach pools are far less constantly supplied with fresh water. The conditions in the latter approach somewhat those of the ill-drained inland sloughs between the sandy ridges. By far the most characteristic plant about the pool margins is *Juncus Balticus littoralis;* this species is more xerophytic than most of its genus, and often creeps well up on the xerophytic upper beach. *Triglochin maritima*, *Potentilla Anserina* and several species of Salix also occur about the margins of the pools.

4. *Fossil beaches.*

In regions where dunes are superposed upon the beach, portions of the beach may remain unoccupied by the wind-blown sand, appearing as islands in a sea of dunes. Or a beach which has been covered by the dune-complex may later be uncovered, exposing the gravel and shingle of an ancient shore. In any case these ancient or fossil beaches, separated as they are from the present beach by dunes, are more highly protected from the wind than the beaches which have been previously described. The cold winds lose little of their energy while sweeping up the gradual slopes of an ordinary beach, but their force is considerably broken by a line of dunes. Fossil beaches which have been uncovered by the dune complex occur at Dune Park, but to such a limited extent that a typical flora is not developed.

The most extensive fossil beach observed was at Glen Haven, where an area several hectares in extent has been denuded of its covering of sand to help supply the extensive dune complex. Similar but smaller fossil beaches were seen at Saugatuck and North Manitou island. Associated with the fossil beach is a formation which may not represent a beach at all. In the general description of the region, reference was made to the high terrace-like bluffs along the northern portions of the lake shore. These miniature plateaux, from which former sand dunes have doubtless been removed, exhibit a surface of gravel, which produces the appearance of a fossil or a true beach. The most extensive of these flat gravel-topped hills are at Glen Haven; similar but less extensive formations of this type were seen at Frankfort and North Manitou island.

The floras of the fossil beaches and the gravel terraces 120 meters above the present beach are essentially identical, although the latter apparently have a greater exposure. Both the beaches and terraces have a flora which resembles that of the upper beach in a general way, but there is a pronounced decrease of most of the typical beach forms and a pronounced increase of the more inland types. Thus the flora clearly illustrates the greater protection from exposure which is enjoyed on the fossil beach. The Artemisias are as characteristic of the fossil beaches and terraces as of the upper beach, but none of their five chief beach associates retain their prominence here. *Cnicus Pitcheri* occurs frequently, but chiefly at the lower level; *Euphorbia polygonifolia* and *Œnothera biennis* were observed but rarely and only at the lower level; Lathyrus, Corispermum, and Agropyrum were not found at all. In place of these upper beach plants the Artemisias have a new crowd of associates. In general the terraces and fossil beaches have four dominant character plants, *Artemisia Canadensis* (or *A. caudata*) as already named, *Solidago humilis Gillmani*, *Lithospermum hirtum* and *Andropogon scoparius*. Solidago and Lithospermum were noted as occurring at times on the upper beach, but they are far more common here. Andropogon was not observed on the true beach, but is very common on fossil beaches and terraces, its scattered bunches or tufts forming one of the chief landscape features.

On the more northern fossil beaches several species are almost as characteristic as those named in the preceding paragraph. Prominent among these forms are *Zygadenus elegans*, *Campanula rotundifolia arctica*, and *Arenaria Michauxii;* northward these types are almost wholly confined to the fossil beaches or terraces, although Zygadenus is sometimes present on the upper beach. *Anemone multifida*, *Kœleria cristata* (?) and *Arabis lyrata* occur northward but are less frequent. A very interesting plant which sometimes frequents fossil beaches is *Hudsonia tomentosa*, a species noted for its habit of forming scattered clumps of densely tufted growths. Other occasional tenants of the terraces and fossil beaches are *Populus monilifera*, *Prunus pumila*, *Calamagrostis longifolia*, and *Solidago nemoralis*.

While the fossil beach looks backward to a true beach history, it commonly looks forward to a heath. Largely protected from the accumulation of sand, they furnish a situation favorable for the development of a juniper-bearberry heath. Such heaths are in process of formation at Manistee, North Manitou and elsewhere, and will be described in another place.

B. THE EMBRYONIC OR STATIONARY BEACH DUNES.

1. *Dunes of rapid growth* (*primary embryonic dunes*).

Many of the lake winds which blow across the beach have a surplus of energy, and are able to select out the finer grains of sand and carry them farther from the shore. The action of the wind in transportation is analogous to that of water. The finer particles are picked up bodily by the air currents, while the larger particles are blown or rolled along on the beach. Whenever an obstacle is met, some or all of the load is necessarily deposited by the wind. The coarser particles are deposited upon or about the obstacle, while the finer particles form a diminishing trail on the lee side. As soon as the deposition is sufficient to relieve the overladen wind, the trailing of sand ceases, and the wind continues with its lessened load until another obstacle is reached So long as the wind blows continuously from one direction, the mound of sand keeps growing and the trail to the leeward becomes more and more conspicuous. Indeed, the growth increment is often greater during the later stages of a continuous wind current, since the growing mound of sand becomes more and more an obstacle to the progress of the laden wind. As a result of this action, there appears a topographic form with a steep windward side and a gently sloping leeward side.

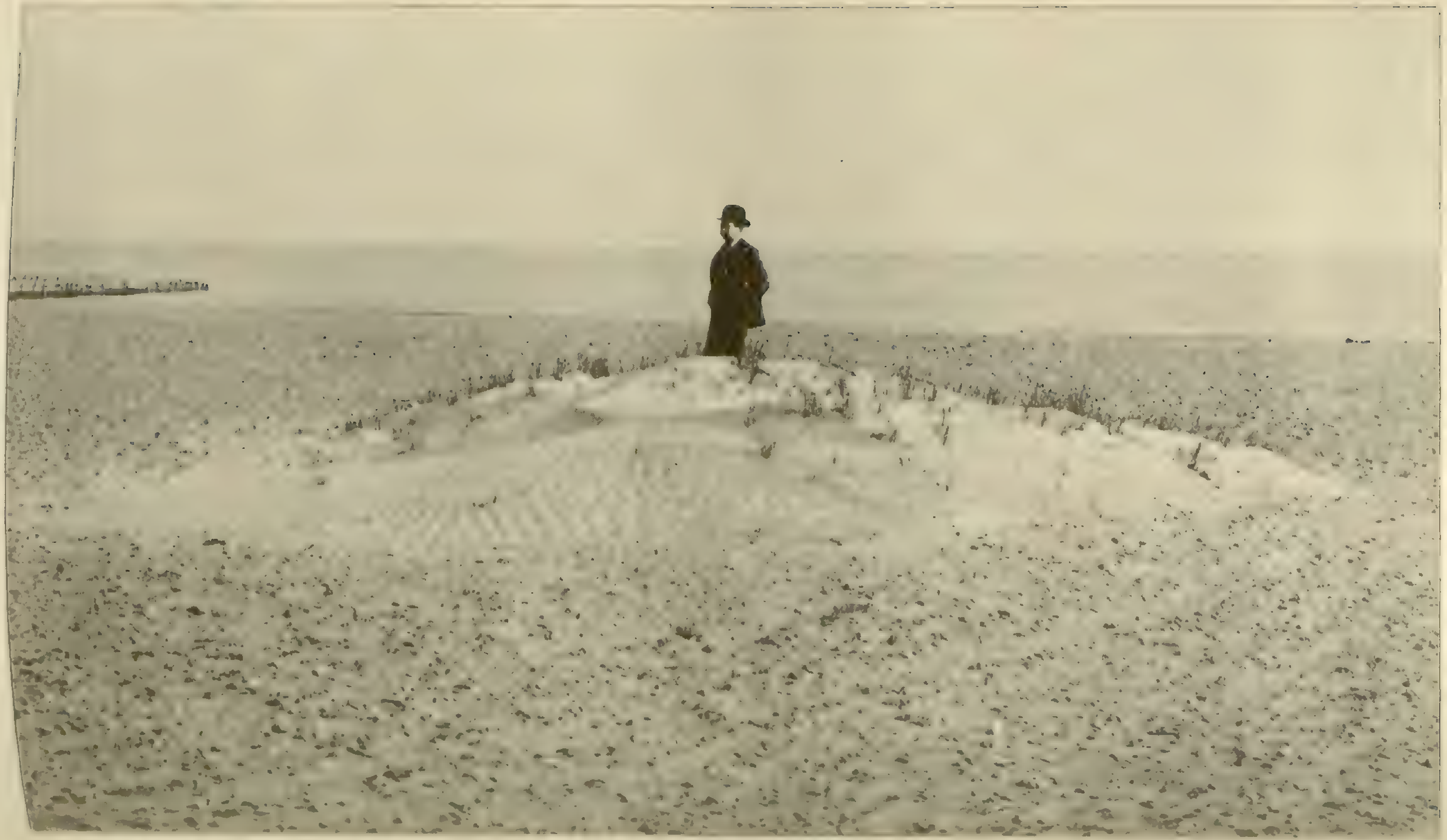
When the wind changes, the trails of sand are no longer in the lee of the obstacle, but are more or less exposed to the wind, and hence are rapidly removed. The contour of the mound is changed and there results, just as before, a topographic form, steep to the windward but gently sloping to the leeward. It will thus be seen that it is always possible in dry weather to determine the direction of the last strong wind by observing the position and direction of the leeward trails of sand. A clump of grass with a poorly developed leeward trail may be seen in the foreground of *fig. 4*.

Under ordinary conditions no permanent results follow from such wind action as has been described, since one wind destroys the products of another. There is, perhaps, a tendency for sand to accumulate on the landward side of obstacles, since the energy of the lake winds is likely to be greater than the energy of winds from other directions. But no extensive dune formation can occur on the beach, unless the obstacle, which compels the wind to deposit its load, is itself increasing in size. A mound of sand, which is being built up by the wind, becomes more and more a formidable obstacle to the progress of the sand-laden currents, and it might be supposed that the growth of such a mound would continue indefinitely. Such does not appear to be the case on the beaches studied. The wind blows over the beach from so many directions and with such resistless energy that mounds of sand rarely accumulate without the aid of other factors.

The formation of beach dunes, then, depends upon something more than wind and sand. An obstacle is needed which will grow *pari passu* with the dune, and such an obstacle is furnished by a number of perennial plants, which spread by means of rhizome propagation. These dune-forming plants must be perennials; otherwise the dune would be destroyed at the end of the growing season. Such annual dunes are very common on the beach. Clumps of Cakile have been seen, about which there is piled a miniature dune. In the same manner there may be formed biennial dunes about individual plants of Artemisia or Cnicus. A perennial dune, however, requires perennial dune-formers. A second necessity in a dune-former is the ability to spread radially by rhizome propagation, for only in this way can the area of the obstacle and the area of the dune be enlarged. The only notable exception to this rule is found in the case of cottonwoods and such perennial grasses as Andropogon and Elymus; these plants grow in groups or tufts and will be described later.

The plant which serves as an obstacle for the wind must also possess the power of growing out into the light when buried by the sand. This property permits the rise of the dune in altitude, as rhizome propagation permits the increase in area. Most plants are excluded by reason of this third requirement, partly because they are unable to rise above the sand when buried, and partly because stem elongation increases the difficulty of drawing up a sufficient supply of water from the soil. The roots of dune plants are often uncovered and exposed to wind and sand-blast action; hence plants unable to survive a period of root exposure cannot live in such a habitat. In short, a successful dune-former must be able at any moment to adapt its stem to a root environment or its root to a stem environment. The vicissitudes of existence on an embryonic dune are greater than anywhere else, except at a few points on the dune-complex. In addition to the above particular requirements, a dune-former must, of course, be perfectly equipped with a set of the most extreme xerophytic adaptations. Nowhere else except on the beach is there so great exposure to heat, cold, and wind.

The most typical and successful of all dune-forming plants



[illegible] the beach at South Chicago, formed by the sand reed, *Ammophila arundinacea.* Leeward trail of sand at the left.

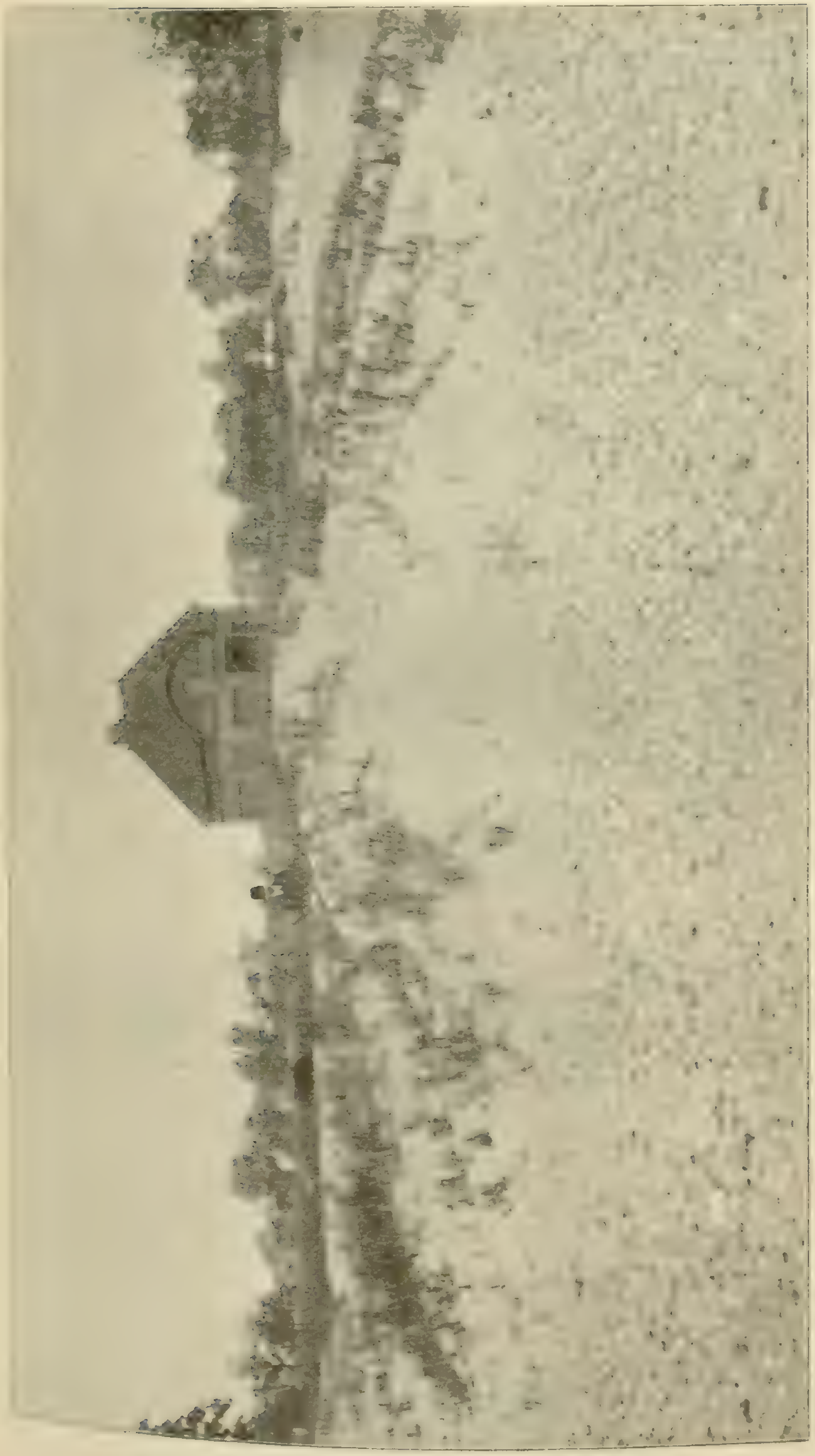


Fig. 3.—Embryonic Ammophila dune on the beach at South Chicago, some years older than that shown in *fig. 2*. Sinuous trough at the center, where there is no vegetation.

along Lake Michigan is the sand reed, *Ammophila arundinacea.* The life history of an Ammophila dune will now be given, and may be taken as the average life history of a stationary beach dune. Whenever a tuft of this or any similar grass gets a foothold on the upper beach, the sand drifts along and is lodged in between the stems and leaves, as already described (see foreground, *fig. 4*). The leeward trail of sand changes its position as the wind varies its direction, but the sand deposited between and around the blades of grass is not easily dislodged. The radial propagation of the tuft of grass causes an areal extension of the miniature dune. So, too, there is an increase in altitude, since the grass constantly grows higher in its endeavor to lift itself above the sand. This upward growth enables more sand to accumulate; in other words, the grass and the dune grow *pari passu* outwards and upwards. The result of several years of this symbiotic growth of dune and grass may be seen in *fig. 2*, which represents a small embryonic dune on the beach at South Chicago, Ill. The general contour of the dune is seen to be determined by the Ammophila; toward the left is the leeward trail of sand left by the last wind. *Fig. 3* represents an older and larger Ammophila dune on the same beach, viewed from the lakeward side and hence not showing any leeward trail of sand. Not only is the general contour of this dune determined by the Ammophila, but there will be observed a somewhat sinuous trough toward the center, where there happens to be no vegetation. This shows how readily the dune would be removed were it not for the plant life present. Thus Ammophila is not only an efficient dune-former but also a dune-holder.

While Ammophila is the most common dune-former and perhaps the best adapted for that difficult task of all our lake shore plants, many other species play a similar rôle. On the northern beaches *Agropyrum dasystachyum* is very common as a dune-former; its habit is exactly that of Ammophila, and consequently needs no description. *Elymus Canadensis* and *Calamagrostis longifolia* may be regarded as dune-formers, but they are of less importance than Ammophila and Agropyrum. A

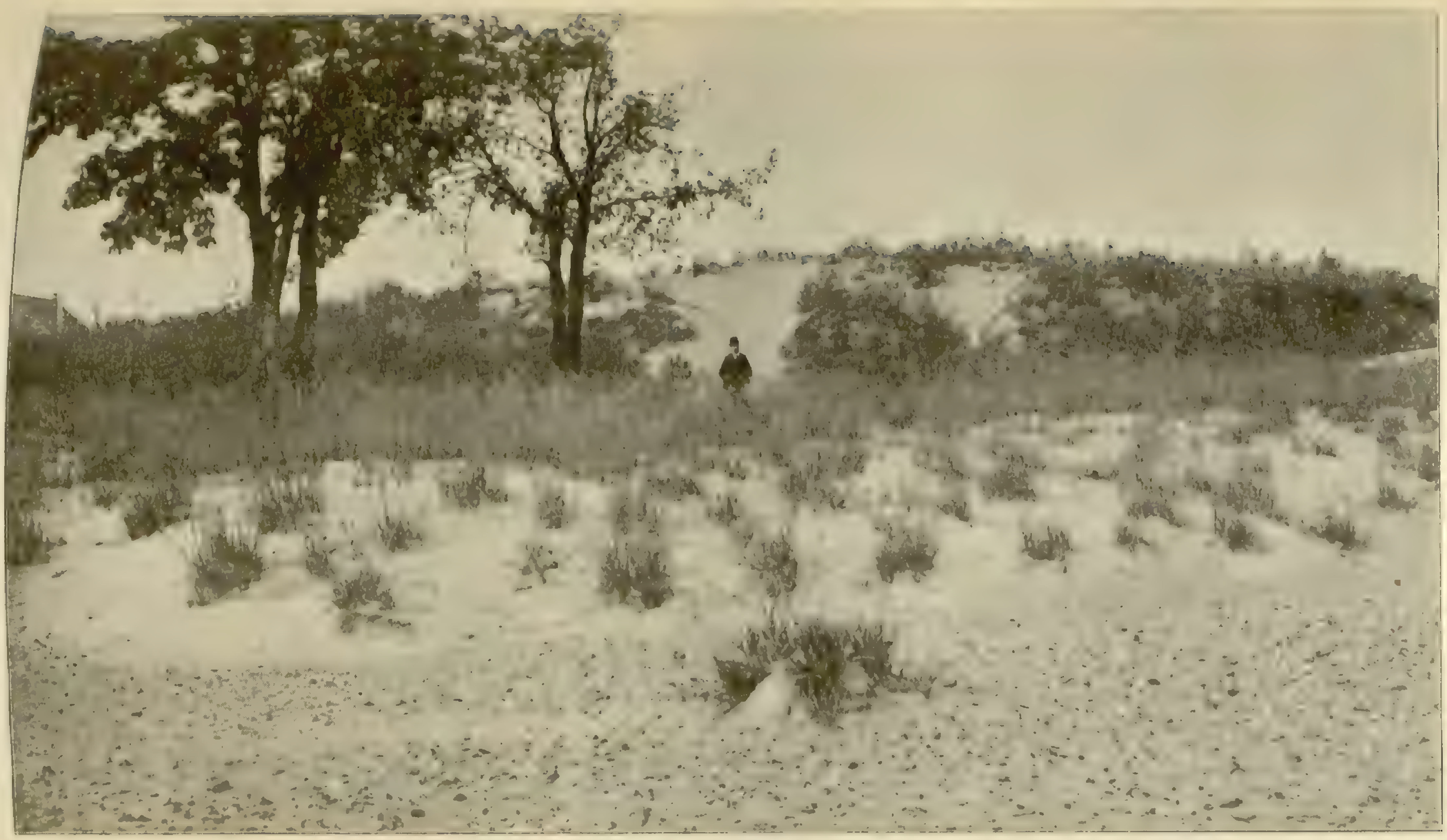


FIG. 4.—Embryonic dunes on the South Chicago beach. Tuft of grass in the foreground just beginning to collect sand, also with a leeward trail. Dune at the center formed by many tufts of Elymus acting together.

typical Elymus dune, as found on the South Chicago upper beach, is represented at the center of *fig. 4*. These grasses grow in tufts and do not have any extensive vegetative propagation, but the tufts may be so close together as to act like a large social clump of Ammophila.

Certain shrubs are of almost equal importance as dune-builders with the grasses. Among these, the willows, *Salix adenophylla* and *S. glaucophylla*, and the sand cherry, *Prunus pumila* deserve especial mention. All of these shrubs have social habits, and rapidly increase their area of control in all directions. The willows are particularly well fitted to build up a perennial beach dune. They are about as well adapted to a xerophytic environment as are any of the grasses, and their vegetative increase is about as rapid. The fact that they are shrubs and have a greater power of vertical stem elongation makes them even better fitted to rise above the sand. When a shoot of one of these willows is buried, roots are sent out from all the buried portions, even up as far as the floral axis. The willows, too, can be uncovered without suffering serious injury. In short, the species of Salix are able to adapt their stems to a root environment, or *vice versa*, better than any other plants found along the coast. Hence the willows stand abreast of Ammophila as dune-formers. Another shrub that seems to have all the necessary requirements for a dune-builder is *Cornus stolonifera* (or *C. Baileyi*), though it is probably less fitted for a xerophytic life; however, Cornus dunes are by no means rare on the beach.

The only trees which make any significant contribution to dune formation are the poplars, *Populus monilifera* and *P. balsamifera*. Of these, the former is the more important, especially southward. These trees have little or no vegetative propagation of the willow type. Every year great numbers of cottonwood seeds germinate in protected depressions on the upper beach. As the young plants grow rapidly, it is not long before they form groups dense enough to retard the sand-laden winds. Thus a cottonwood dune is formed, a type which characterizes the Lake Michigan shore at very many places. A cottonwood dune

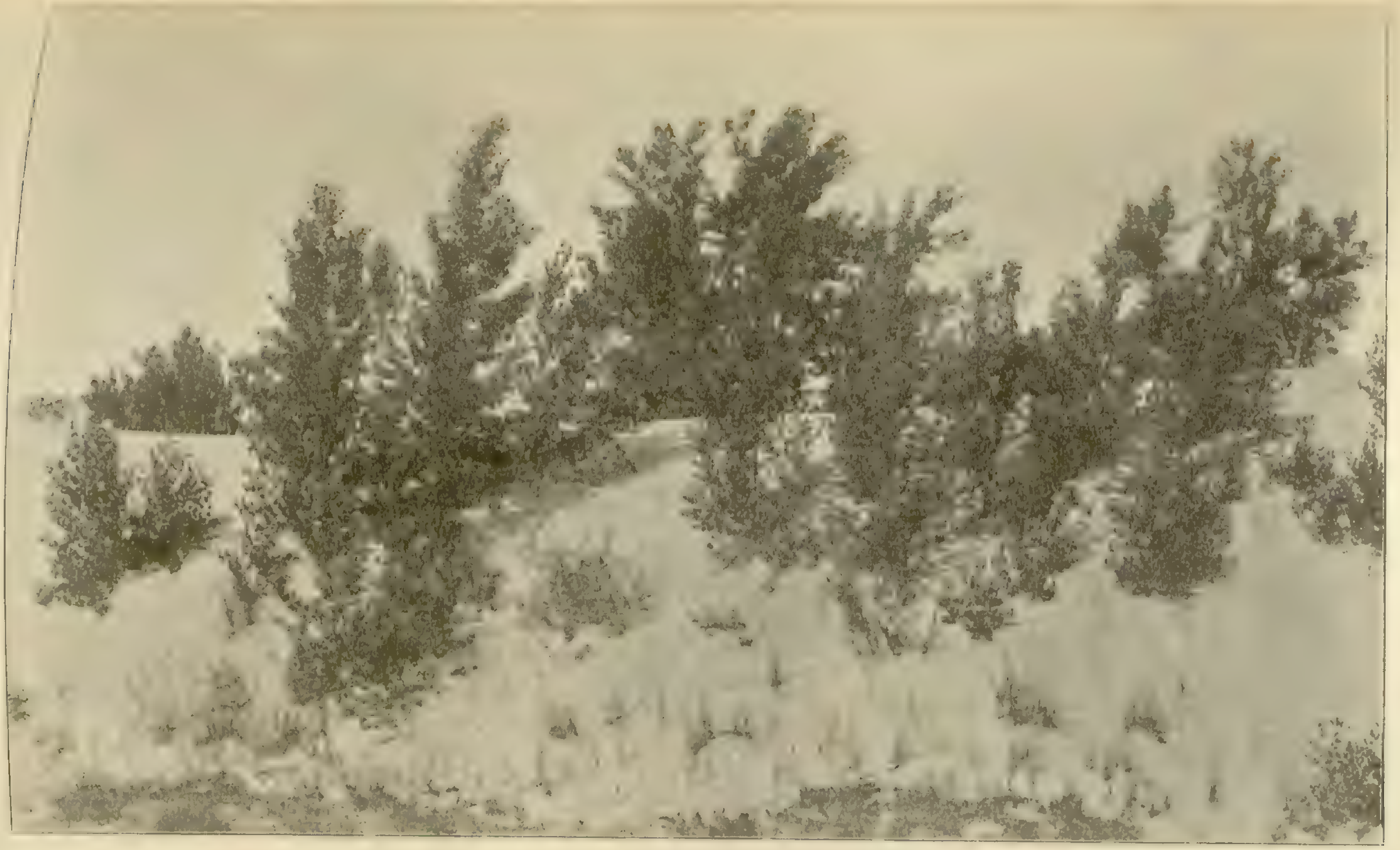


FIG. 5.—Embryonic dune at Dune Park, formed by the cottonwood, *Populus monilifera;* viewed from the leeward side. Trees partially buried. Steepness of slope shown by the streaking of the sand. Tendency of vegetation to creep up the lee slope.

a number of years old is shown in *fig. 5*. It is possible to see, even from the photograph, that the lower portions of the trees are covered by the sand. The growth of a cottonwood dune, therefore, is of a symbiotic nature, exactly as is the growth of an Ammophila dune, in spite of the great difference between the life habits of these two dune-formers.

The controlling part which plants play in dune formation is still further shown by the variations among the embryonic dunes as to area, shape, and height. Dunes that are formed by Agropyrum, Ammophila, or Salix are capable of indefinite areal expansion, since these plant types have extensive vegetative propagation. Populus or Elymus dunes, on the other hand, always retain essentially the same area, since there is little or no vegetative reproduction, and since the opportunity for any further development of seedlings is removed. Young seedlings are often found in the moist sand of the depressions, but never in the dry sand of the dunes. The Agropyrum dunes are always very low, seldom if ever a meter in altitude. The Ammophila dunes are higher because this latter plant type has a greater power of upward growth than has the former. Both the Agropyrum and Ammophila dunes are alike in being relatively large and low, with slopes almost as gentle as those of the beach. The Salix dunes are equally large, but higher and steeper because of the greater power of upward growth. The Prunus dunes are very small because of the slight vegetative propagation, and yet they are relatively high and steep because of the pronounced power of upward growth.

The cottonwood dunes are the highest of all, often having an altitude of several meters, because the cottonwoods grow higher than any other dune-former; they are also the steepest because there is no vegetative propagation. The steep slope of a cottonwood dune is shown in *fig. 5;* the marks in the sand at the right are the paths made by the movement of the sand down the steep slope, and indicate a gradient of about 30°. *Figs. 2* and *3* indicate the gentle slope of the Ammophila dunes. The cottonwood dunes are commonly long ridges parallel to the lake shore. This is partly due to the fact that the depressions in which the seeds germinate are parallel to the shore, because of wave action. The prevalence of lake winds perpendicular to these ridges also helps these topographic forms to retain their original shape. Summing up this matter, then, the area of a beach dune is determined chiefly by the amount of the vegetative propagation of its tenants, the steepness is determined by the rapidity of this propagation, and the altitude by the power of the dune plants to increase in height.

Of the dune-forming species, *Ammophila arundinacea* and *Salix adenophylla* are the most abundant, occurring almost everywhere that beach dunes exist. These two species are most at home when half-buried in the wind-blown sand, and occur much less frequently in other associations. *Prunus pumila* and *Calamagrostis longifolia* occur throughout the region, but are less characteristic of the beach dunes than are the first-named species. Prunus is common on the upper beach, as already shown, and also on the heath; Calamagrostis is particularly characteristic of the larger active dunes. *Agropyrum dasystachyum* is very common at Glen Haven and farther north, and, like Ammophila, is most at home on the beach dunes. *Populus monilifera* is very common south of Glen Haven; the cottonwood dunes are usually formed farther inland than the other types. This species is replaced northward to some extent by *Populus balsamifera* and its variety *candicans* (both sometimes on the same tree!), though this poplar is much less of a dune-former than the cottonwood. *Salix glaucophylla* is frequent on the beach dunes, especially southward, but is more characteristic of the swamps; the same may be said of *Cornus stolonifera*. *Elymus Canadensis* is not abundant anywhere on the beach dunes.

An interesting corollary may be deduced from the last three paragraphs. Since various dune forms are caused by differences in the life habits of the dune-forming species, it follows that the distribution of certain topographic forms coincides with the distribution of the dune-formers. Low dunes of the Agropyrum type are not found at the south end of the lake. The steep ridgelike cottonwood dunes are common southward, but rarer northward, since cottonwoods are rarer northward. This is only one of the many cases where ecology helps to interpret physiography.

The dune-forming plants are not the only tenants of the beach dunes. Most of the species that grow on the upper beach are also frequently present on the dunes. Those of especial importance are *Artemisia Canadensis* (or *A. caudata*), *Cnicus Pitcheri*, *Lathyrus maritimus*, *Euphorbia polygonifolia*, and *Corispermum hyssopifolium.* By reason of its extensive vegetative propagation, *Juncus Balticus littoralis* sometimes serves as an obstacle to sand-laden winds, and by a limited subsequent growth results in the formation of miniature dunes. *Lithospermum hirtum* though more characteristic of embryonic heaths and rejuvenated dunes, sometimes ventures out upon the beach dunes. It should be likewise noted that any of the dune-forming species are likely to grow on dunes that are formed in the main by others, although the vegetation of individual embryonic dunes is often composed of a single species.

Though no plant formation anywhere can have a much larger percentage of plants that are entirely independent of other plants, the beach dunes, nevertheless, have occasional forms that are parasitic, saprophytic, or epiphytic. Various unidentified Basidiomycetes have been found in the most open places, deriving their nutriment from buried driftwood. The most notable parasite found was *Aphyllon fasciculatum*, a plant which derives its nutriment through attachment to the roots of Artemisia. Lichens are abundant on the cottonwoods at all places that are not directly exposed to a fierce sand-blast action. Common lichen species in such places are *Physcia stellaris*, *Theloschistes concolor*, and *Placodium sp.*

Interesting beach dunes were seen on the shores of two small inland lakes, Crystal lake, near Frankfort, and Fount lake, on Beaver island. In each case the lakes approach a dune area near the shore of Lake Michigan, suggesting the probable origin of the sand; there can be no question, however, but that the sand composing these beach dunes was washed up by the waves of the small inland lakes and worked over by the winds, exactly as described in the preceding pages. The dune-forming winds at Crystal lake are easterly winds, chiefly because the source of sand is on the west side of the lake, and it is on the west shore that the dunes are located. There are typical Ammophila dunes at this point. Among the other plants growing here are Artemisia, Cnicus, Populus, Cornus, Prunus, Lathyrus, Œnothera, Corispermum, Calamagrostis, Elymus, and Juncus. At no place on Lake Michigan was a more typical and varied beach and beach dune flora observed than on the west shore of Crystal lake.

2. *Dunes of slow growth* (*secondary embryonic dunes*).

Dune formation is by no means confined to the upper beach, but may take place anywhere that the sand is able to collect, provided the plants at that place are fitted to be dune-formers. The formation of dunes on the dune-complex and on rejuvenated dunes is essentially like that on the upper beach, and will be discussed later. New dunes of a very interesting type are in process of formation on many fossil beaches and on the gravel terraces. As has been previously stated, the terraces and fossil beaches are better protected from the wind than is the upper beach, and there is in consequence not only a more luxuriant flora, but also a different plant assemblage. The sand which blows across these places, though less in quantity and less furiously driven, nevertheless is capable of dune formation if the proper plant species are present. Several of the beach dune-formers also occur on the terraces and fossil beaches, and build up small dunes. Among these are Ammophila, Calamagrostis, Prunus, and Populus.

Among the dune-formers on terraces and protected fossil beaches, one of the most interesting is *Andropogon scoparius*. This grass grows in tufts and is very abundant, as has been already stated. About each tuft a mound of sand has often collected. A photograph showing the striking appearance of an area of Andropogon dunes was unfortunately spoiled, but its appearance is much like that of an area of *roches moutonnées*, as figured in geological works. Hundreds and sometimes thousands of these miniature dunes may be seen in a single landscape. *Arctostaphylos Uva-ursi* and *Juniperus Sabina procumbens* are dune-formers within moderate limits. Both of these shrubs are procumbent creepers, and hence unable to rise above the sand to any considerable height, probably never as much as a meter above their original position. It is for this reason that such hardy plants as these cannot grow successfully on an upper beach that is exposed to extensive sand drifting. The above three species are the most prominent dune-formers in protected places. Arctostaphylos dunes occur throughout, and are not confined to fossil beaches, but are also common on exposed heaths. The Andropogon dunes were not seen except on fossil beaches, although this grass is common along the entire coast. The Juniperus dunes occur chiefly northward.

The dune formation seen on east coasts was chiefly of the small, slow-growing, secondary type. The dunes at Waukegan, in part at least, are formed by Juniperus. On the east shore of Beaver and North Manitou islands, there are a number of low dunes formed conjointly by Juniperus and Arctostaphylos. There are low slow-growing Juniperus dunes on the shore of Fount lake on Beaver island; in addition to the procumbent juniper, *Juniperus communis* and *Gaylussacia resinosa* assist in dune building here. The Andropogon dunes are better developed on the fossil beaches of North Manitou island than at any other point visited. On these same fossil beaches, *Hudsonia tomentosa* serves in a small degree to collect the wind-blown sand. On the east shore of North Manitou island, the pasture grass, *Poa compressa* forms miniature dunes.

Near the beach at South Chicago there are swampy depressions tenanted by *Potentilla Anserina* and *Polygonum Hartwrightii*, plants which are best developed in low grounds but which often creep up to higher levels. On these higher levels near the beach they collect the drifting sand and are able to form low dunes similar to Arctostaphylos. These plants show a most surprising plasticity, since a single individual developed in a swamp is able to adapt itself to a mild type of dune existence. Another swamp plant, *Cephalanthus occidentalis*, occurs near the same beach and in a similar way helps to build these low slow-growing dunes. The conversion of swamp plants to dune plants will be discussed more at length in another place.

The most extensive area of dune formation on the beach was seen on the west shore of Beaver island. *Fig. 6* shows a small portion of this area. This place is of peculiar interest because there is a perfect series of gradations between the rapidly growing dunes first described and those of the slower growing type. Toward the beach proper (foreground, *fig. 6*) there are dunes formed by Salix, Prunus, and other high-grade dune-builders. Farther back, toward the taller and older dunes

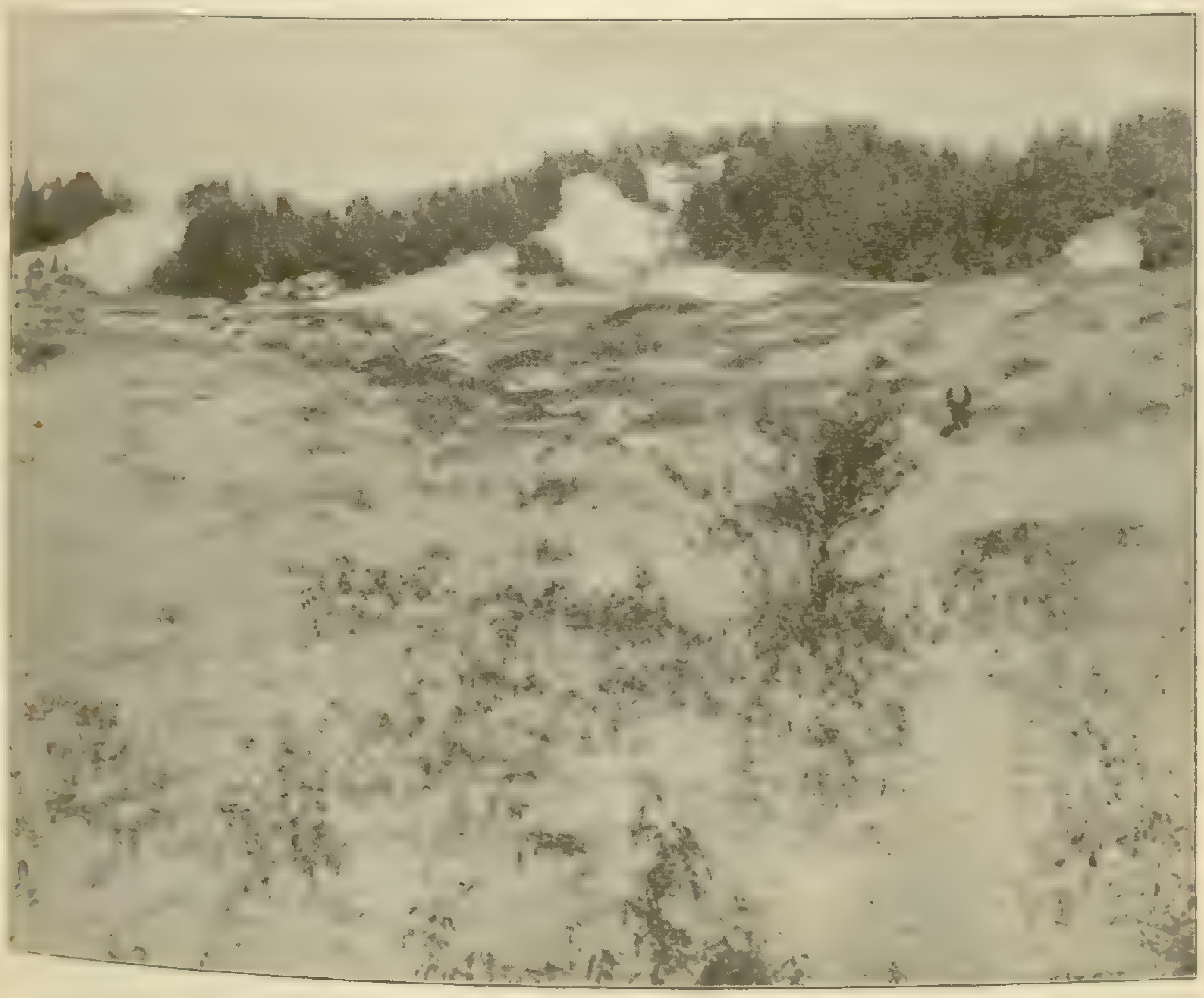


FIG. 6.—Embryonic beach dunes at Beaver island. Primary Prunus and Salix dunes in the foreground. Secondary Arctostaphylos dunes superposed on primary dunes, at the center of the picture. Old lines of established coniferous dunes in the background, becoming rejuvenated at several points.

of a previous epoch, there may be seen low dunes built by Arctostaphylos, Juniperus, and *Potentilla fruticosa*, small dune excrescences on a general dune substratum. The life-history of these dunes appears to have been as follows. First a stage of dune formation by such plants as Salix, then, as vegetative propagation allowed these plants to encroach more and more lakeward upon the broad beach, new dunes were formed nearer and nearer the lake. Or, perhaps, there was a recession of the lake and a consequent extension of the beach into new territory; these new dunes may have thus been formed farther and farther lakeward, keeping pace with the advancing shore line. In any event, the interposition of a new row of dunes between the lake and those first formed essentially changed the life conditions on the latter. The row of dunes nearest the lake serves as a windbreak. The first row catches most of the drifting sand, and the second catches most of what remains. This fact makes it possible for the slow dune-formers to inhabit the more inland of the ridges. Expressed in other words, the high-grade or primary embryonic dunes encroach upon the lake, not by the actual advance of an individual dune in that direction, but by the formation of new ones; in like manner the low-grade or secondary embryonic dunes encroach upon the former type, using the topographic form of the primary dune as a base of operations, and building new dunes as low excrescences upon the old.

The advance of a dune area toward the lake, as just described, shows how the coastal belt of dunes may grow wider as the years pass by. In another place it will be shown how they may also grow wider by the actual advance of an individual dune upon the land. In concluding the section on the embryonic dunes, it may be well to emphasize in another way the radical difference between the two types that have been discussed. Their intimate gradation, as shown at Beaver island, is by no means the universal fact. Perhaps it is even more common for one of the primary type to leave its original habitat and wander across the country as an active dune. The secondary type never has that history; an Arctostaphylos dune almost always grows into a heath.

C. THE ACTIVE OR WANDERING DUNES. THE DUNE-COMPLEX.

1. *Transformation of stationary into wandering dunes.*

The symbiotic growth of the beach dunes and their builders may go on for years, but a prolonged existence of these relations is unlikely. As the mounds get larger and higher the conditions for further accumulation of sand become, if anything, more favorable. It is not so with the plant tenants, for each year they are raised farther from their chief base of supplies, the water level. It is probable, also, that the desiccating influence of radiant energy and wind upon the aerial organs becomes greater and greater as the years go on, because of greater exposure at the higher levels. Again, the dune-formers, although perennials, do not have an indefinite duration. The life cycle of the cottonwood is relatively short for a tree. All of the other prominent dune-formers spread more or less by vegetative propagation, so that it is difficult to determine a definite life cycle. Even though an existence of indefinite duration might be secured through vegetative propagation, many individual shoots must die in the course of time.

In one way or another, then, dune formation ceases and another phase of dune history begins. There is here an end of the stationary beach dunes, a beginning of the wandering dunes. When the plants are no longer able to oppose its progress, the first effect of the untrammeled action of the wind is seen in a tendency to reshape the topographic forms. The beach dunes heretofore described are more or less symmetrical, because of the tendency toward symmetrical plant growth. A dune fashioned entirely by the winds without the assistance of plants is never symmetrical. The windward slope has a very gentle gradient, usually about 5°, and because of the destructive action of the wind, this slope is topographically rough and uneven. The leeward slope, however, is much steeper, averaging about 30°, and is very smooth and even, because determined by gravity instead of wind. The wind sweeps up the gentle windward slopes, blowing or rolling the sand along until the crest is reached; here the sand is deposited by the wind and it rolls down the steep slope, spreading itself quite evenly. *Fig. 17* shows an average gentle windward slope, *figs. 13–15* steep leeward slopes.

The Prunus dunes are particularly favorable for a study of the origin of an active dune, since their form is most at variance with that of the wind-shaped dune, as described above. A Prunus dune is commonly a low cone more or less rounded at the top. As soon as the plants are dead, and sometimes long before that event occurs, the wind endeavors to reduce the windward gradient by removing the sand toward the top and blowing it over on the other side. In this way the roots are exposed and existence made less endurable, if the plant is still living. Prunus dunes with roots exposed on the windward side are common at Dune Park, Beaver island, and elsewhere. On the terrace at Glen Haven, some dunes have been carried beyond their former resting place, leaving the scraggy clumps of Prunus roots at the rear.

What has been said of the Prunus dunes holds more or less for the other types. The cottonwood dunes especially are peculiarly subject to the destructive attacks of the wind, since their shape also notably fails to correspond with that of a normal wind-made topographic form. The lower Ammophila, Salix, and Agropyrum dunes are less likely to suffer destruction, and yet small Ammophila dunes were seen on the dune-complex at Glen Haven that had been blown away from their first abode, leaving the Ammophila stranded at the rear. Even while living, these dune-formers were unable to hold the dunes which they had helped the wind to build; much more when dead are they likely to have the dune swept on beyond them.

The destructive action of the wind and the transformation of a stationary into an active dune are very much retarded by the tenacity with which the stems and roots retain their place, even when dead. A plant which thus has the power to hold its position and keep the sand from being blown away is commonly called a sand-binder. In this connection it may also be called a dune-holder, as it has been already called a dune-former.

Perhaps the most tenacious of all the dune-holders on the coast of Lake Michigan is *Calamagrostis longifolia.* This grass, as has been seen, is not of first importance as a dune-builder, but when it has once built up a dune it seems almost impossible to dislodge it. At the left of the basswood tree in *fig. 23*, there is shown a clump of Calamagrostis directly facing the prevailing wind at the summit of a mound, and stubbornly holding its position. The leaves, stems, and roots are all stiff and wiry, almost perfectly resisting the mechanical action of the wind. The roots in the sand form a network so dense that it is almost impossible for the wind to remove the sand from among them.

From an economic standpoint, *Ammophila arundinacea* is a more successful dune-holder than is Calamagrostis, but its greater success is due to its extensive vegetative propagation. The dense social growths of Ammophila make it difficult for the wind to get a start in the process of sand removal, whereas the sand can be readily picked up from between the more scattered tufts of Calamagrostis. An individual tuft of the latter, however, seems to be much more resistant than a tuft of Ammophila. Calamagrostis, too, grows in more exposed situations than does the other grass, and hence is a valuable dune-holder in places where Ammophila might not thrive at all.

Another noteworthy dune-holder is *Prunus pumila.* A very common sight on the upper beach is a truncated cone literally covered at the summit and sometimes on the sides with a dense tangle of dead stems and roots of the sand cherry. The wind has removed all the sand which it can reach and is obliged to wait until the stems and roots decay sufficiently to allow the wind to blow them away and get at the sand beneath. Prunus is one of the first plants to succumb before the dune in the process of dune formation; perhaps its life cycle is normally short, but more probably the process of drawing up water a greater and greater distance each year compels the plant to give up the unequal struggle.

Sooner or later the dead roots and stems of the dune-holders are all removed, and the wind becomes the undisputed master of the situation. If there is a sufficient amount of sand still remaining, the once stationary dune begins to move, not bodily, of course, but none the less steadily and surely. The sand is swept up the low gradient of the windward side, deposited at the crest, and carried down the steep leeward slope by gravitation. In this manner successive parallel layers of the windward slope are carried over the crest, and the dune as a whole advances inland. The simple life-history just outlined is the exception, not the rule. Much more commonly the sand is scattered in many directions, collecting wherever new lodging places can be found. These processes of deposition and removal, dune formation and dune destruction, are constantly going on with seeming lawlessness. However, in the district as a whole the sand is constantly increasing in quantity, whatever may be true of the individual dunes here and there. The outcome is certain to be a wandering dune in the process of time, unless the actions of the wind and wave are checked. Because of the complexity of the conditions when the movement across the country becomes a conspicuous fact, it seems well to apply the term dune-complex to the totality of topographic forms which make up the moving landscape as a whole.

2. *Physical and biological features of the dune-complex.*

It will not be necessary to trace farther the changes involved in the transformation of simple beach dunes into a dune-complex, although the coast of Lake Michigan shows all of the intervening stages. Inasmuch as a single dune-complex illustrates almost all conceivable conditions of a dune's life-history, a careful description of a typical dune-complex will involve all of the essential points. The dune-complex is best developed at Glen Haven, Mich., and Dune Park, Ind. All of the essential features are present in both areas, though developed on a grander scale at Glen Haven. The Dune Park area has been most carefully studied, and most of my photographs were taken there.

The dune-complex is a restless maze. It is a maze because all things that a dune ever does are accomplished there. While there is a general advance of the complex as a whole in the direction of the prevailing winds, individual portions are advancing in all directions in which winds ever blow. It is not at all uncommon to find small dunes advancing over the dune-complex back toward the lake. At Dune Park the main line of advance is southeast, yet some small dunes advance toward the northwest, because taller dunes are situated between them and the lake. These little dunes in the lee of large ones are protected from the westerly and northerly winds but feel the full force of the easterly and southerly winds, and hence advance contrary to the prevailing direction. It is thus a common sight to see two dunes advancing to meet each other; when they come together, of course the two dunes become one and move in the direction of the prevailing winds. From this account it is easy to see that small dunes on the complex may advance in any direction, provided only that they are protected from winds blowing in other directions.

The dune-complex, however, is much more than a maze of little dunes wandering in all directions. At many points there are to be found the stationary embryonic dunes that have been previously described. All stages of their life-history may be seen; the beginning, the climax, the destruction. Here and there the wind sweeps out great hollows, which reach down almost to the water level. Great troughs are carved out by the wind, chiefly at right angles to the lake, but also at all other angles. Here and there vegetation has obtained a foothold on the complex, thus converting portions of it into an established dune. These established dunes may become rejuvenated, or the vegetation may spread until it covers large portions of the complex. The most striking feature of the dune-complex, then, is its topographic diversity.

To one who visits a dune-complex season after season, another feature comes to be as striking as its diversity, and that is its restlessness. From a distance the complex seems always the same, a barren scene of monotony, but the details are never twice alike. A little dune arising on the complex has become enlarged, another has passed from existence without leaving a trace behind. Where a dune was advancing last year, there is now, perhaps, a hollow swept out by the wind. Where last year was a hollow there may now be seen the beginnings of a flora, or again the flora of a former year may have been buried out of sight. The dune-complex, then, is not only a maze, but also a restless maze.

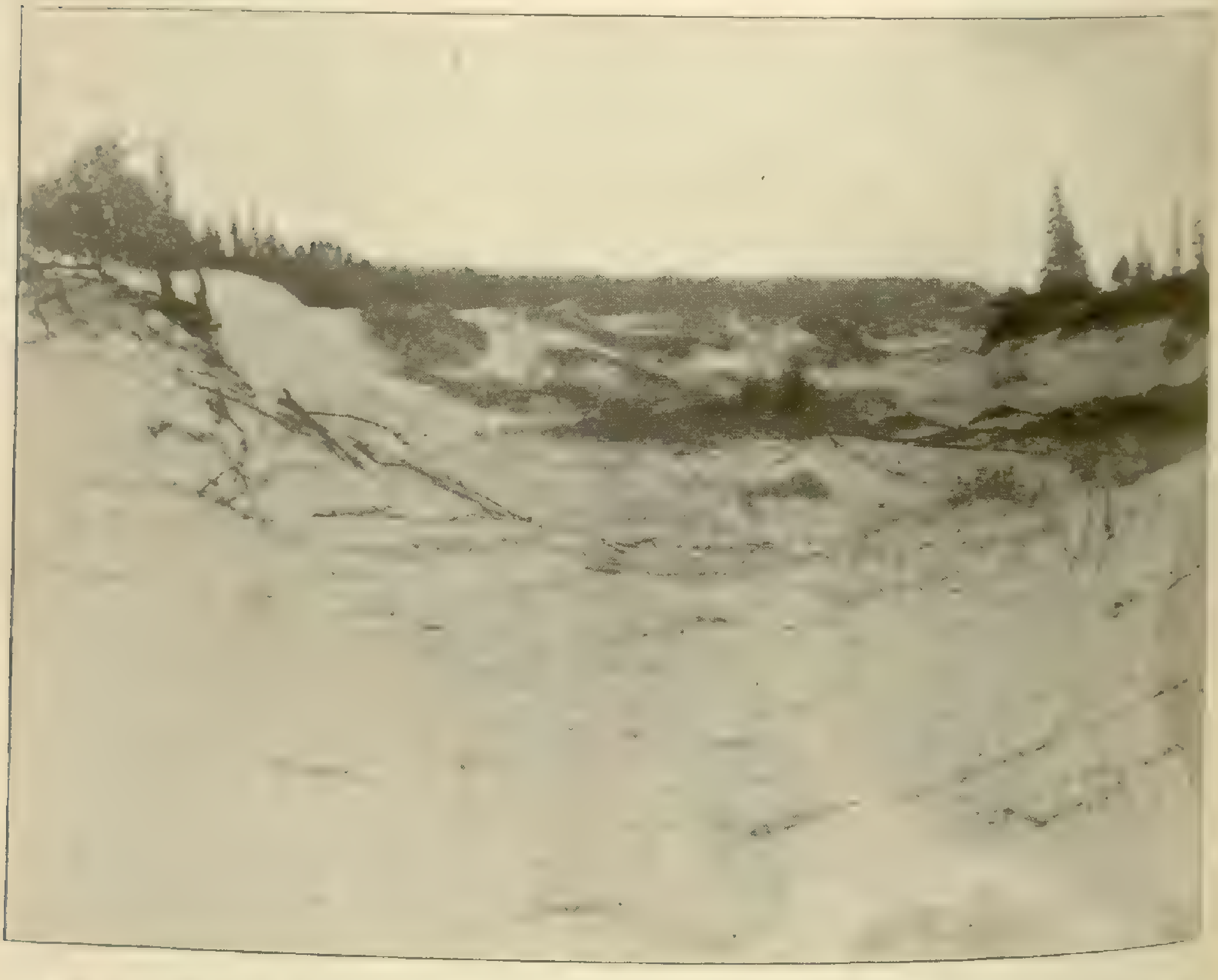


FIG. 7.—Trough-shaped wind-sweep at Beaver island. Dead roots and branches of plants that have been torn up. Embryonic dunes in the background formed of sand brought from the foreground. Sparse annual vegetation in the wind-sweep.

It might seem impossible to unravel the tangled threads of the dune-complex; it is, indeed, impossible to write the details of its history. There is, however, a simplicity in the complexity. While little dunes advance in all directions, the complex as a whole advances in the direction of the prevailing wind. While there are troughs at all angles, the main troughs are likewise in the direction of the wind. The complex is like a river with its side currents and eddies at many points, but with the main current in one direction.

It has already been stated that the windward slope of an advancing dune is very gentle, averaging perhaps about 5°. That portion of the windward slope up which the main wind currents pass is also trough-shaped and may be called a wind-sweep. *Fig. 7* shows a small trough-shaped wind-sweep at Beaver island; the direction of advance is from the foreground to the background. In the path of the wind there may be seen dead branches, the remnants of a vegetation that has been swept away. In the background are small dunes which have been formed by sand carried along the trough by the wind. A wind-sweep more characteristic of the dune-complex is shown in *fig. 17*. Here, likewise, the prevailing wind direction is up the gentle slope away from the foreground. At this particular place there is in reality much more of a trough than is shown in the photograph, since there is a conspicuous rise both at the right and at the left. Just beyond the pines in the background there is a steep pitch downward, the advancing lee slope.

The most remarkable wind-sweep at Dune Park reaches down almost to the water level, appearing like a cañon, by reason of its steep sides from ten to twenty meters in height. This sweep, unlike most of the troughs, is curved so that a wind entering it as a northwest wind becomes a west and finally a southwest wind, and actually contributes to the advance of a dune toward the lake, as will be discussed more fully at another place in connection with *fig. 10*. The concentration of the wind energy which these gorge-like wind-sweeps permit is something remarkable. At no place is the destructive power of the wind upon the vegetation felt more keenly than along the sides of these deeper wind-sweeps. The foreground of *fig. 22* shows the upper part of one of these troughs, and gives a vivid impression of the wind's destructiveness.

The advancing lee slopes, as has been previously mentioned, have a gradient in the neighborhood of 30°. The slope is exactly that at which sand, whose grains have the size and cohesiveness there found, will lie. *Figs. 9, 13, 14*, and *15* give some conception of the striking features presented by a landscape of which an advancing dune forms a part. Nowhere can there be a sharper line in nature, nowhere a more abrupt transition. The height of these slopes above the country on which they are advancing varies from almost nothing up to thirty meters at Dune Park. The Glen Haven dunes are far more imposing, since there is an almost unbroken line of advance for four kilometers, while the average height is from thirty to sixty meters above the territory on which they are encroaching.

The vegetation of the complex proper is exceedingly sparse. In the winter it appears almost a barren waste. The one plant which seems to be at home in all locations, whether wind-swept exposed summits, or protected lees, is the bugseed, *Corispermum hyssopifolium*. This plant is an annual, and has been previously mentioned as a tenant of the beach and the beach dunes. The bugseed is shown in several of the photographs, but best in the left foreground of *fig. 12*. The seeds are winged and readily dispersed by the wind. Furthermore they germinate rapidly during wet spring weather. This power of rapid germination is a necessary condition of success, since the surface layers of sand dry off very quickly after the wet weather has ceased. The plants are obliged not only to germinate rapidly but also to send roots deep enough to reach beyond the surface desiccation. Even this perfectly successful plant species is often absent from large areas on the dune-complex, probably because of the difficulty which the seeds meet in finding lodgment. It is only an exceptional seed which is allowed to remain stranded on the complex, and many of the seeds which succeed in finding lodgment are likely to be buried too far below the surface to permit germination.

Another plant which deserves especial mention is the cottonwood, *Populus monilifera*. The plasticity of this species is remarkable. Normally at home along protected river bottoms, it is yet able to endure almost all of the severe conditions of the dune-complex. Mention has been made of its importance as a

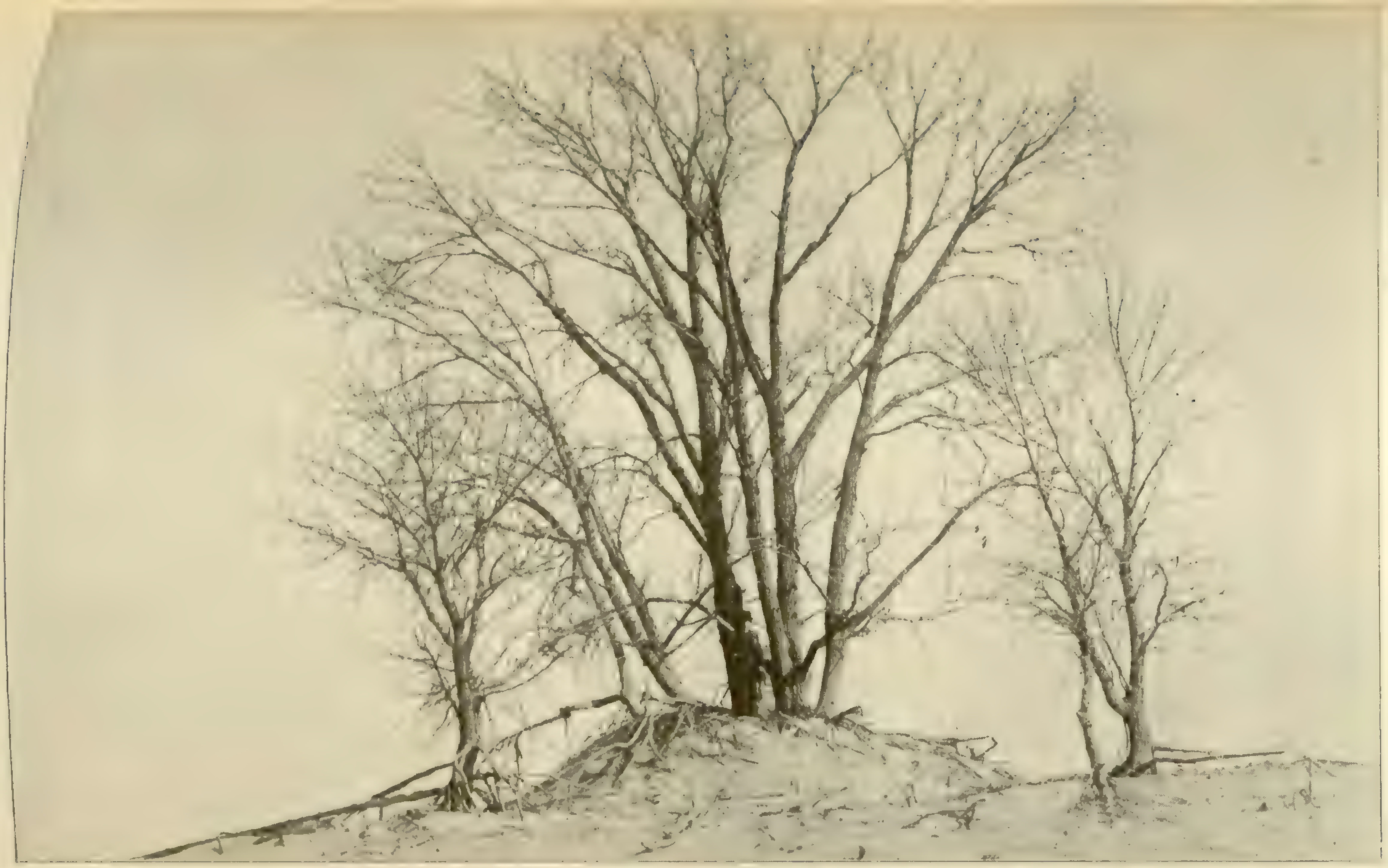


Fig. 8.—Group of cottonwoods (*Populus monilifera*) at an exposed position on the dune complex at Dune Park. Exposure of roots, due to denuding action of the wind. View taken in winter.

dune-former, and *fig. 5* shows a group of cottonwoods on an embryonic dune partially buried by the sand. Photographs might have been secured showing trees, presumably fifteen meters in height, buried up to the topmost branches and yet alive and vigorous. *Fig. 8* (taken in the winter) shows a vigorous clump of trees, high up on the dune-complex, with their roots exposed by reason of the removal of the sand from around them. Much more striking examples than this have been seen of living trees standing high up in the air, and yet with no apparent injury. In one respect the cottonwood is a hardier plant than Corispermum; it is a perennial and hence passes the winter on the dunes. In the summer the winds are much more moderate, and the chances of being covered or uncovered are more remote.

Two grasses are more or less at home at many places on the complex, *Ammophila arundinacea* and *Calamagrostis longifolia*. Of these the latter is the hardiest and most typical of exposed positions, such as shown at the left in *fig. 23*. The tenacity with which Calamagrostis holds its ground has already been mentioned. On the Glen Haven complex, Ammophila is particularly abundant. In some places it is so thick and green as to look almost like a field of grain from a distance; yet even here, the luxuriant growth is only in the protected places, and none at all is found in the most exposed situations.

The reasons for the scanty plant life on the exposed portions of the dune-complex are not far to seek. First of all it is not due to the scarcity of water in the soil. Even after a long period of drought in summer, the sand is cool and moist at a short distance below the surface. The upper dry layers of sand act as a non-conductor of heat and prevent the evaporation of the water that lies beneath. The height of the underground water level beneath the dunes was not ascertained. Indeed it is not at all necessary to determine where this level actually resides, since there is enough water far above it to support a luxuriant vegetation, if that were the only factor concerned.

In spite of the water supply in the dune sand, the scanty flora of the complex is characterized by the possession of the most pronounced xerophytic adaptations to be found in this latitude. These xerophytic structures will be discussed in the second part of this paper. At this point it is necessary only to state that in the main they are to guard against excessive transpiration, such as is induced by the unusual exposure to wind, heat, and cold. In a certain measure one might attribute these xerophytic adaptations to an insufficient amount of water in the soil, since, were they absent, the soil water would soon be used up. But it is much more important to discriminate, as ecologists are now coming to do, between conditions in the soil and those in the air. A plant may have its roots in the water and yet be exposed to a xerophytic air; in that case the aerial organs will be provided with xerophytic adaptations, as is the bulrush. Schimper, in his recent plant geography, goes still farther and calls some plants hygrophytic at one season and xerophytic at another. Perhaps the ultimate definition of a xerophyte will be a plant that is endeavoring to reduce its transpiration.

Directly or indirectly, the wind is the factor primarily responsible for the scarcity of vegetation on the dune-complex. Incidentally, as has been stated, the wind dries up the soil and increases transpiration. Incidentally, too, the mechanical action of the wind in connection with the sand-blast is destructive to vegetation. The cardinal destructive influence of the wind, however, consists in its power to cover and uncover the dune plants. Two plants have been referred to as peculiarly well adapted to dune life, Corispermum and Populus. The former is a small herb, and unable to endure either covering or uncovering to any great extent. This plant, however, is an annual of short duration and does not exist during the periods of the greatest wind activity.

The cottonwood, which has been shown to be best fitted to withstand the instability of dune conditions, might be expected at first to grow in abundance there. It has almost unlimited powers of endurance in all conditions of exposure; it may be covered to the upper branches, or may have its roots uncovered to a depth of two or three meters, and yet flourish. Its failure to make any considerable headway on the complex is due partly to its relative inability to extend its area by vegetative propagation, partly to its short life cycle, and partly to the impossibility of germination. Thus a group of cottonwoods, which germinated when the conditions were more favorable and have been able to withstand the severe environment of the dune-complex, cannot appreciably extend their area, nor can they live for many years. New trees cannot take their place, because of the inability of the cottonwood seed to germinate on the higher exposed portions of the complex. These seeds sprout much more slowly than those of the bugseed, nor could the young plants withstand the winter conditions on the complex, even should they germinate. Furthermore, the likelihood of any considerable lodgment of cottonwood seeds is excluded by their light cottony appendages.

THE UNIVERSITY OF CHICAGO.

[*To be concluded.*]

BRIEFER ARTICLES.

A NEW COLLETOTRICHUM DISEASE OF THE PANSY.

(WITH FIGURES)

DURING the past season a leaf-spot disease affecting the cultivated pansy has been observed in several localities in Massachusetts, which has been found to be caused by a hitherto undescribed fungus. In at least one instance the disease has shown itself to be a very destructive one, and a consideration of its economic importance will be found in the annual report of the Hatch Experiment Station of the Massachusetts Agricultural College for 1898. Professor B. D. Halsted informs me that the same thing has been found in several places in New Jersey, though not abundantly, and has very kindly sent me specimens for comparison. It is the purpose of this note to describe this form, which seems likely to become abundant in this section at least.

The disease is characterized by the appearance upon affected leaves of dead spots, at first small with a distinct black margin, but soon becoming larger and giving the leaf an appearance very similar to that produced by the well-known violet leaf-spot (*Cercospora Violæ* Sacc.). The petals also become affected, dying in spots and on the edges. Many of them do not develop fully, and thus the blossom appears malformed and unsightly. Such flowers produce no seed and in a large field of pansies raised for seed, where the disease has been seen at its worst, a considerable loss was experienced on this account. Besides this, moreover, many plants were killed outright, making the damage still greater.

The fungus which causes this trouble is a form which evidently belongs in the genus *Colletotrichum*, though in very fully developed material forms are found which closely approach *Vermicularia*, the acervuli having a considerably developed pycnidium. The species apparently stands near the boundary line between these two genera (if one exists), but comes closer to *Colletotrichum* as generally understood. I append a description of this form, for which I propose the name

Colletotrichum Violæ-tricoloris, n. sp.— Parasitic on leaves and petals of cultivated pansy, *Viola tricolor* L., causing pale yellowish spots upon the leaves and dead areas on the petals, together with more or less deformation of the blossoms. Spots at first orbicular and definite in outline but later becoming confluent and irregular. Acervuli numerous, 50–150 μ in diameter, often confluent; stroma usually only slightly developed but sometimes abundant and forming a sort of pycnidium, closely approaching *Vermicularia*. Setæ mostly single or in pairs, 20–70 μ long, deep brown, once or twice septate, tapering gradually to a point. Basidia short, hyaline. Conidia oblong or slightly curved, with blunt ends; hyaline, continuous, granular with vacuoles; averaging 20 × 5 μ.— RALPH E. SMITH, *Amherst, Mass.*

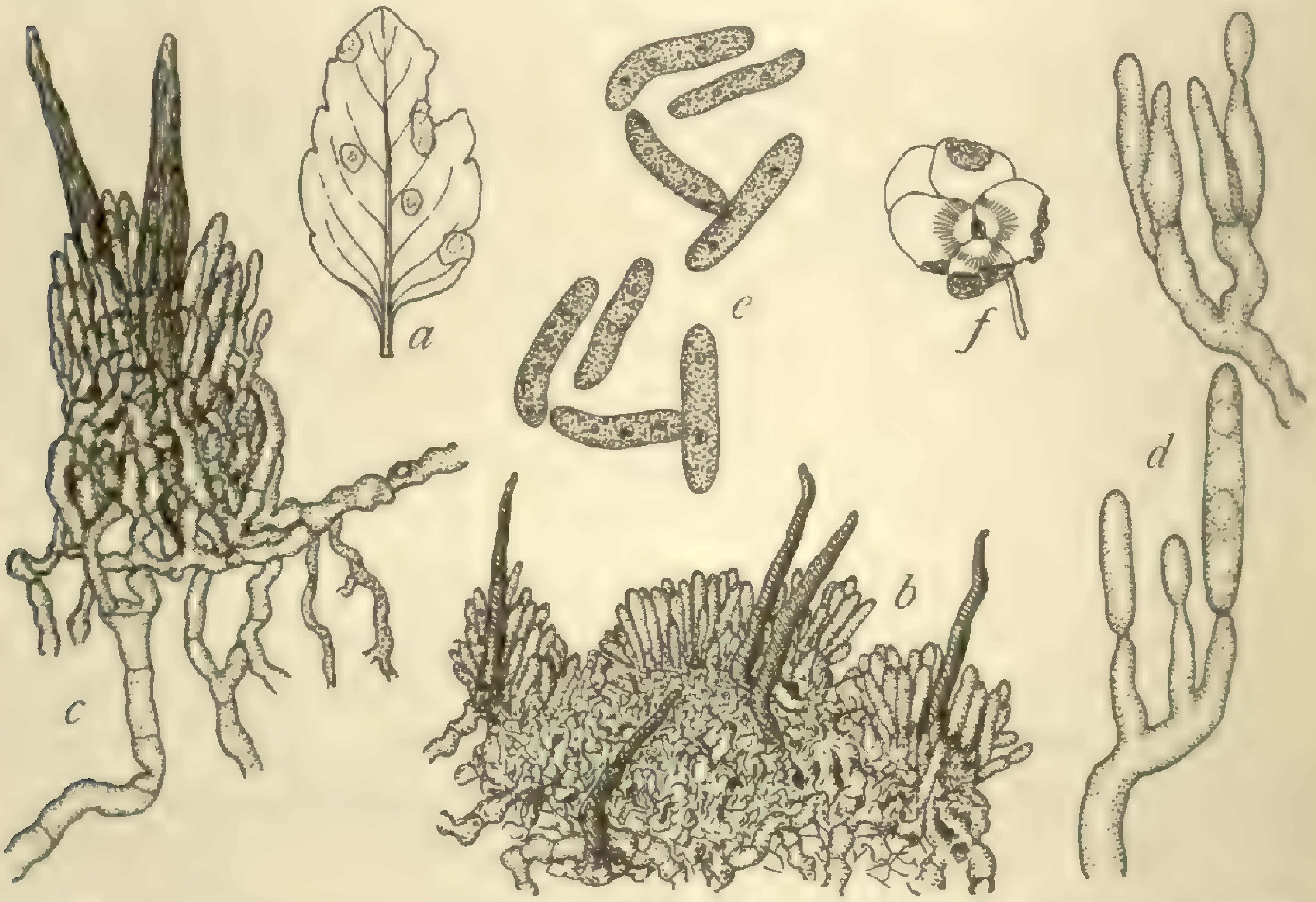


FIG. 1. COLLETOTRICHUM VIOLÆ-TRICOLORIS R. E. Smith: *a*, affected leaflet; *b*, several confluent acervuli with mycelium, setæ, and conidia; *c*, single acervulus, more enlarged; *d*, basidia and production of conidia; *e*, conidia; *f*, affected blossom.

A NEW BIENNIAL-FRUITED OAK.

(WITH PLATES II, III)

Quercus ellipsoidalis, n. sp.— Trees 3–10^{dm} in diameter, 8–20^{m} tall with an oblong head, the spray fine and repeatedly dividing, the limbs often descending low down on the trunk and the lowermost drooping. The bark is close, rather smooth, divided by shallow fissures into row, thin, flat plates, 5–15^{cm} long, 1.5–3.5^{cm} thick, frequently connected by cross plates. It is darkish colored near the ground, dull gray above and grayish-brown among the branches, where it is quite smooth and but little furrowed. It is coarsely cellular, dull red within, with a thin band of yellow or yellowish bark 1–2^{mm} thick next the wood. The smaller branches are lustrous, the older being green tinged with red. Those of the second year are greenish-brown to olivaceous, those of the year brown to reddish-brown, both often mottled with spots or areas of gray. The younger are well furnished with small, grayish, oblong or roundish, raised lenticels. The winter buds are 4–8^{mm} long, ovate, obtuse or acutish, sometimes slightly angled. The scales are ovate to oval, ciliolate, the outer brown to reddish-brown, with a rusty or grayish pubescence, the apex blunt or rounded. The unfolding leaves are spreading or a little drooping, often slightly tinged with red, densely covered with white tomentum, giving the foliage a silvery-gray appearance. The stipules are 12–15^{mm} long, scarious or membranaceous, caducous, oblanceolate-linear to linear, hairy on the margin and with a few scattered hairs on the surface. The leaves soon become smooth and lustrous green above, lighter green and smooth beneath or with slight tufts of pale hairs in the axils of the principal veins. They are from 6–15^{cm} long, 5–12^{cm} wide, oval-orbicular or somewhat obovate-orbicular in outline, the broadest part usually just above the middle, and are deeply cut into 5–7 lobes by broad sinuses rounded at the base which extend halfway or nearly to the midrib. The lobes are generally oblong, the terminal broader and somewhat quadrangular, their sides nearly parallel or a little diverging above the middle. They end in three to five triangular teeth with slender bristles. The base of the leaf is bluntly cuneate to truncate, the parenchyma on one side usually a little lower. The petioles are rather slender, 2.5–5^{cm} long (generally about 4^{cm}), usually tinged with red on the upper side. The color of the autumn leaves varies, but in most is yellowish to pale brown, more or less blotched or tinged with red or purple. Some change to a vinous or crimson purple, giving the tree a dark reddish appearance. In the winter they are pale brown.

The aments are in clusters, slender, 5–8^{cm} long, loosely flowered, puberulent, from lateral buds which after flowering may be prolonged into leafy shoots. The calyx is membranaceous, campanulate, usually tinged with vinous red, two to five-lobed, cleft, parted, or divided into oblong, oval, ovate or roundish segments, their shape depending on the number and depth of the divisions. A frequent form of calyx is one divided to the base on the side next to the rachis, the margin two or three-lobed or parted. The segments are smooth or slightly scabrous with a few minute scattered hairs, the tips copiously fringed with long, flattish, twisted or curling hairs. Stamens four or five, about the length of the calyx lobes. Anthers longer than the filaments, oblong, with a cordate base and blunt or emarginate apex which is sometimes apiculate.

The pistillate flowers are from the axils of leaves on fresh shoots of the year, their peduncles stout and very tomentose, and one to three-flowered. The calyx is tubular campanulate, the upper part generally strongly tinged with vinous red, and is four to seven-lobed, cleft or parted, the margin laciniate hairy and fringed with usually long hairs. Styles three, spreading or recurved, thick and flattish, hairy near the base, the enlarged rounded or knoblike stigmas dark colored and slightly two-lobed. The involucral scales are hairy, commonly reddish, mostly broad and blunt-pointed. There is often a basal lanceolate and bract-like scale. The acorns are single or in pairs, the cup turbinate or cup-shaped, thinnish, covering one third to one half or more of the nut and commonly tapering into a peduncle 8–15^{mm} long. In some forms the cup is thickened near the margin, forming a kind of shoulder (*plate II, f*). The scales are narrow-ovate, obtuse or truncate, brownish, pubescent, closely appressed, sometimes a little loosened near the rim on drying. The margin is thin, hyaline, and slightly eroded. The cup within is puberulent, pale brown, the thin margin with a more deeply colored, reddish or yellowish ring. The nut is chestnut-brown, often striped with darker lines, puberulent, 12–20^{mm} long, 10–15^{mm} wide, ellipsoidal, varying from a cylindrical to a shorter somewhat globular form. The kernel is pale yellow and bitter, at least to the after taste.

Quercus ellipsoidalis more closely resembles *Q. palustris* in general appearance than the other common biennial oaks of the vicinity. There are also strong reminders of *Q. coccinea* and *Q. velutina*. It shares with *Q. palustris* a comparative smoothness of bark for an oak, the depressed lower limbs often coming low down on the trunk, the finely divided leaves and the general character of its branching, but the lobation of the leaves, the inner bark, and especially the acorns, are different. It has the smoothest bark of any except this and young boles of *Q. rubra*, which it also resembles in the smoothness and color of the trunk after branching, as well as the larger branches themselves, in these characters. The smaller lower branches readily die off like those of *Q. palustris* but do not leave the prominent stubs so characteristic of the pin oak. The tinge of dark color low down on the trunk, the thin layer of yellow bark next to the wood, the coarse-grained wood itself, the presence of hairs in the axils of the veins of the leaf, the relatively dull color of the autumn leaves, suggest *Q. velutina*, but it does not have the roughness and blackness of bark which the black oak shows very early in its growth; there is much less yellow in the bark itself, and it has an acorn different in form and very unlike in the scales of the cup.

When first observed in the fall of 1891, with some misgivings it was called *Q. coccinea*, partly on account of the acorns, which in general appearance are more like some forms of fruit in this species, and partly on account of a tendency to red, of a purple or crimson cast, however, seen in some of the autumn leaves. Its leaves also divide more like those of *Q. coccinea* and it has the reddish tinge of the inner bark, but the leaves do not turn scarlet in autumn, the outer bark is darker colored and much less rough and broken than on boles of *Q. coccinea* of similar age or size. It is also far less lichen-covered than trunks of *Q. coccinea* (generally it is comparatively free from lichens), for the scarlet oak seems preeminently chosen among the black oaks by these plants, which sometimes are so close and large as nearly to conceal the color of the bark and at once reveal its specific character.

Hybridity was thought of and was suggested by others; a cross between *Q. coccinea* and *velutina*, though *palustris* might almost as well be added. But the trees are too numerous to resort to this explanation, even if they had such an origin, which I regard as possible or even probable for species. South of the Calumet river near Halsted street it spreads over an area of several acres, and is equally common south of Glenwood in this county. In the first locality it gives place eastward to *Q. rubra;* in the second it is more commonly associated with *velutina* and *coccinea*. Where first found, at Gardner's Park near the southern limits of Chicago, it also grows with *Q. velutina*, and *rubra* is near by. The soil in this place is sandy, an ancient beach of Lake Michigan, very thin and overlying a heavy clay. Elsewhere it grows in clay soil. Aside from these three localities, that of Glenwood extending northward with scattered trees or areas toward Thornton, I have not detected it elsewhere. But acorns from trees which unfortunately were cut down before they could be fully studied suggest its presence north of the city in the vicinity of Winnetka.

That it differs from the ordinary black oaks to the eye of other than botanical observers is evident from the fact that an intelligent farmer had separated it from its congeners, calling it "yellow oak," and remarking the tendency of the lower limbs to die. No chestnut oaks, to which this name commonly applies, grew there, so that it could in no way be confounded with this, even if the leaves were not so different. Looked at in the summer it gives the impression of great leafiness, the leaves being small as a whole, and of airiness on account of its glossy and finely divided leaves. In the winter it impresses by the glitter of its smooth bright branches when free from leaves, and by its great twigginess, due to the spray repeatedly and finely dividing, forming an irregular network as one looks through it.

As the form of the acorns first suggested specific difference, and on the whole is the most constant characteristic, the name *Quercus ellipsoidalis* seems most appropriate.—E. J. HILL, *Chicago, Ill.*

EXPLANATION OF PLATES II AND III.

PLATE II.—*Quercus ellipsoidalis* Hill.—*a*, Flowering branch, natural size; *b*, staminate flower, enlarged nine diameters; *c*, pistillate flower, enlarged nine diameters; *d*, leaf, natural size; *e*, *f*, acorns, natural size.

PLATE III.—*Quercus ellipsoidalis* Hill.—*a*, Fruiting branch, five sixths natural size; *b*, nut, natural size; *c*, vertical section of nut, natural size; *d*, seed, natural size; *e*, winter branchlet.

THE WYOMING SPECIES OF ANTENNARIA.

MOST valuable and efficient work has been done recently by Drs. Greene[1] and Rydberg[2] in the long neglected genus Antennaria. A critical examination of the material in the Herbarium of the University of Wyoming in the light of these contributions has led to the discovery of a few forms, hitherto undescribed, which seem worthy of specific rank. It has seemed well, also, to make mention of all Wyoming species of which specimens are at hand.

Antennaria reflexa, n. sp.—Low and cespitose, somewhat subterraneous at base, with very short leafy offsets: stems 5–10^{cm} high: leaves

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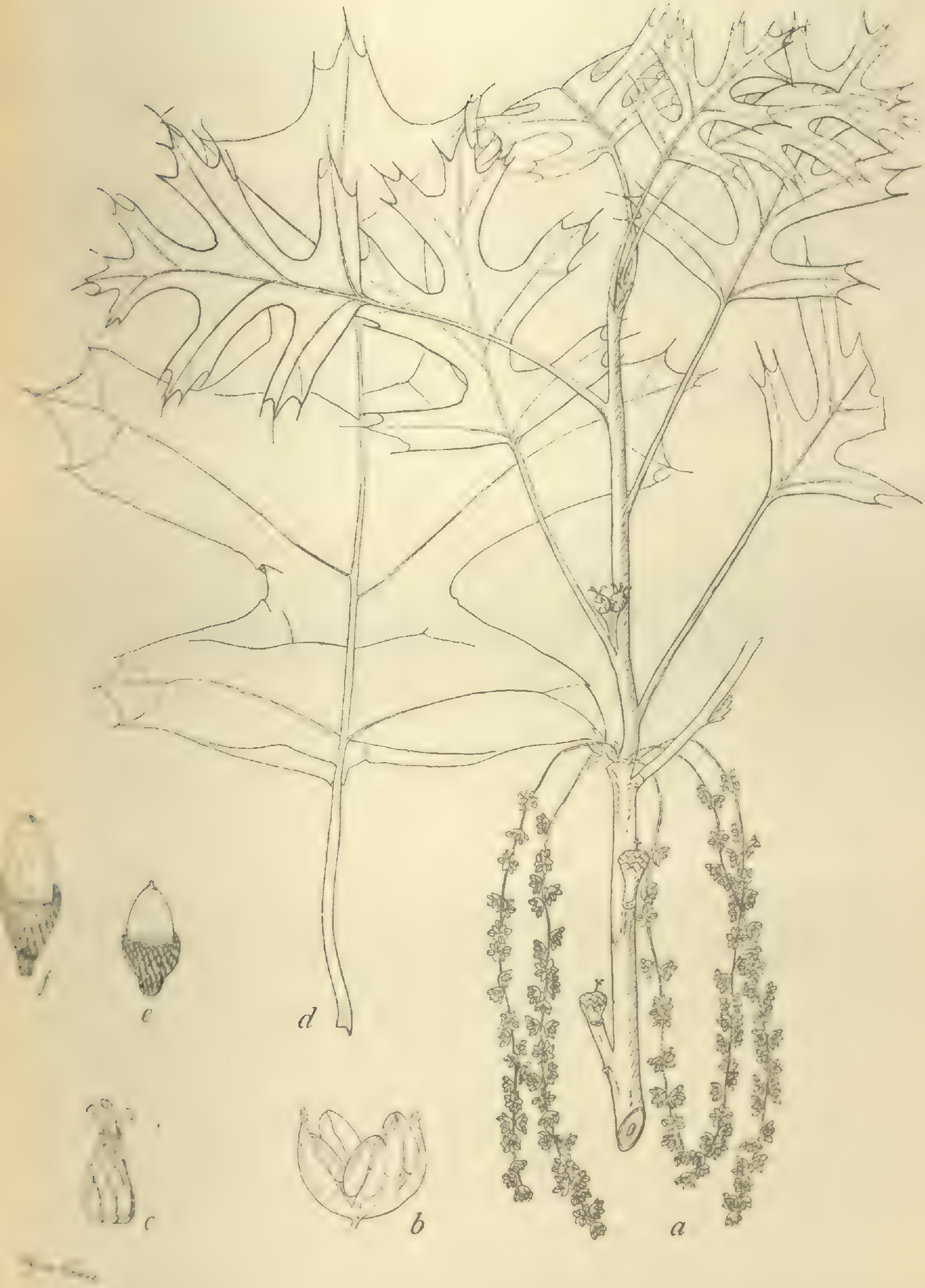
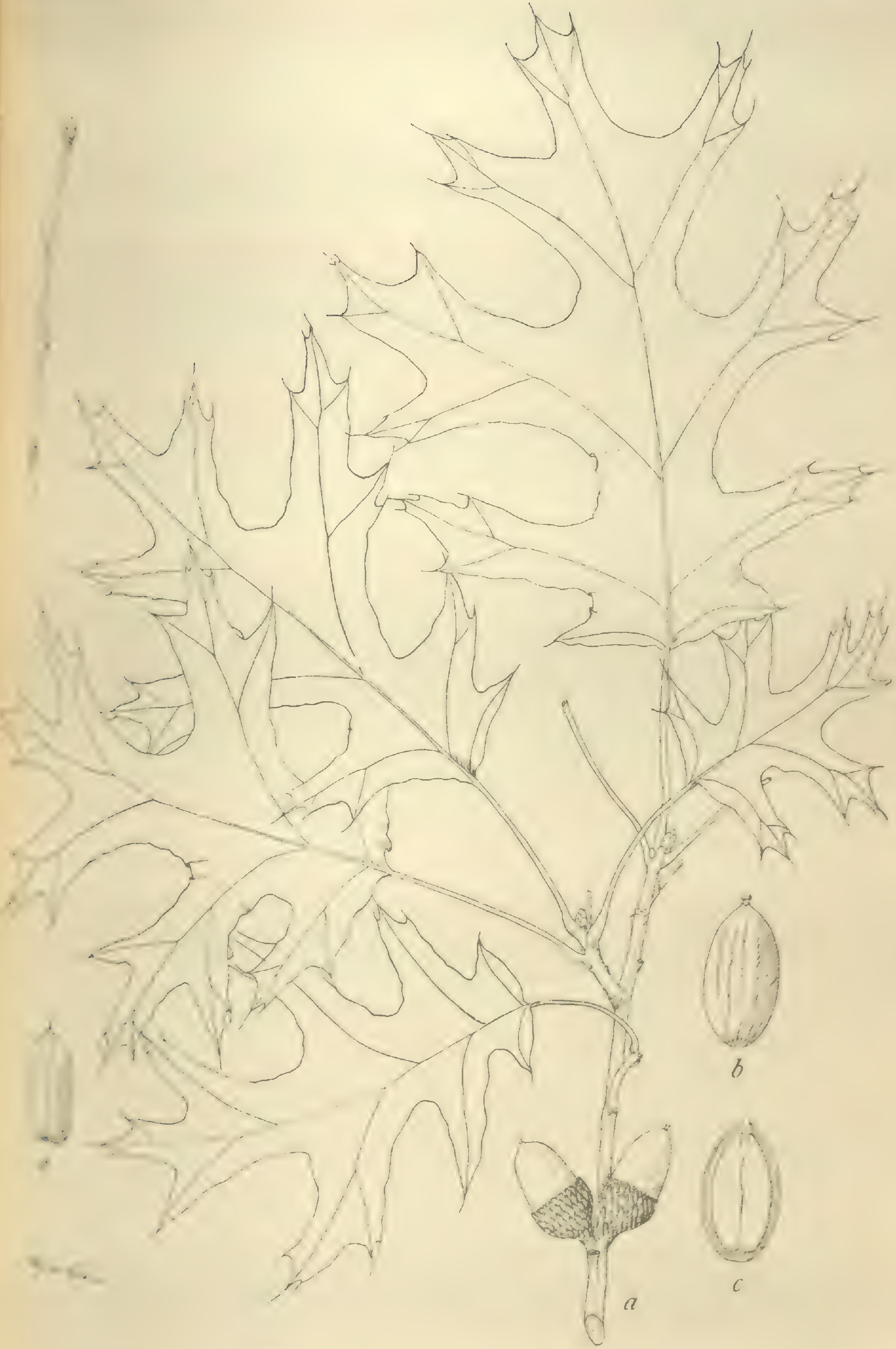
[1] Pittonia 3: 172, 273, 289.

[2] Bull. Torr. Bot. Club 24: 299.



HILL on a NEW OAK.



HILL on a NEW OAK.

spatulate-obovate or spatulate, obtuse to acutish, about 1^{cm} long, rarely more, densely tomentose on both sides; cauline leaves narrowly oblong, obtusish to acute: heads very small, about 4^{mm} high, sessile, 3 to 8 in a close glomerate cluster: involucres very woolly, in the pistillate heads campanulate-cylindrical; bracts of pistillate heads narrow, the inner acute, the scarious portion dark greenish-brown, the outer much shorter, broader, woolly to the tip or almost so; in the staminate heads the scarious portion also dark greenish-brown, oblong-obovate, very obtuse, spreading and becoming reflexed with age: pappus of staminate heads clavellate.

This species differs from all other related forms in that the short outer bracts are woolly to the tip. From *A. umbrinella*, its nearest relative, it differs in its much darker bracts, and acute pistillate ones. It inhabits dry open hillsides at subalpine stations.

Type, no. 1265, in Herb. Univ. of Wyo., from Centennial valley, June 9, 1895: also no. 853, Union Pass, Wind River mountains, Aug. 11, 1894 (both by *Aven Nelson*).

Antennaria mucronata, n. sp.—Loosely cespitose: stems $5-12^{cm}$ high: stolons sparingly leafy, at most 4^{cm} long: leaves oblanceolate or narrowly spatulate, the mucronate tip usually hidden by the tomentum, 2^{cm} long, $3-5^{mm}$ broad, both faces densely woolly-tomentose varying to sparse and hoary, only the lowest on the stolons becoming glabrate: these when glabrate equally so on both sides, with a prominent midrib beneath and an obvious mucronate tip; cauline leaves oblong-linear, acuminate: heads in a subcapitate cluster, sessile or pedicels very short, the lowest occasionally with a pedicel as long as the head: involucres woolly at base; bracts (pistillate) oblong-lanceolate, 5^{mm} long, the obtusish tips usually erose, the scarious portion dark greenish-brown or dark brown, rarely with a white tip.

A very distinct species, from the alpine summits of southeastern Wyoming. From *A. umbrinella* it differs in its longer oblanceolate leaves, its much lighter greenish pistillate bracts, and its lighter tomentum. It is probably more nearly related to *A. media*, but its affinities with that species I have not been able to settle, there being no description of the latter.

Type, no. 5211, in Herb. Univ. of Wyo. from La Plata mines in the Medicine Bow mountains, Aug. 28, 1898; also by *Aven Nelson*, no. 4227, Battle Lake in the Sierra Madre mountains, Aug. 17, 1897.

ANTENNARIA UMBRINELLA Rydb., Bull. Torr. Bot. Club **24**: 302.—This species is represented by only one specimen in this herbarium, collected by Aven Nelson at the head of Green river, Aug. 14, 1894, no. 885. This is far from being typical. The leaves are narrowly oblanceolate, and the pistillate bracts are hardly obtuse. More material of this might prove it to be entirely distinct.

ANTENNARIA APRICA Greene, Pitt. 3:274.—This excellent species is common in the foothills of the Laramie and Medicine Bow mountains, flowering early in the spring on sunny slopes. Many of our specimens have pinkish bracts (pistillate), and often as many as 14 heads in a cluster. The following are the specimens in the herbarium: no. 1266, Centennial valley, June 9, 1895; no. 149, Pole creek, June 3, 1894; Inyan Kara divide Aug. 29, 1892 (*B. C. Buffum*); no. 4347, Plumbago cañon, June 9, 1898.

Antennaria arida, n. sp.—Cespitose, in dense mats formed by the numerous short (1^{cm} high) ascending sterile branches: stems 10-15^{cm} high, slender, wiry, weak above, the subcapitate cluster frequently nodding, loosely covered with shreddy wool: leaves crowded, spatulate, acutish, 0.8-1^{cm} long, densely and permanently hoary tomentose on both sides, inclined to be conduplicate and noticeably so in the younger leaves; cauline leaves oblong linear, acute, lightly hoary-tomentose, more or less twisted and curved: heads 6^{mm} high, sessile, 6-10 in a subcapitate cluster: involucres turbinate; bracts (pistillate) in about two series, all obtuse, scarious portion oblong, milk-white, occasionally the outer with a purplish streak.

A remarkably distinct species, from the arid region of southwestern Wyoming. Type in Herb. Univ. of Wyo., no. 4798, collected by *Aven Nelson* at Tipton, June 17, 1898.

Antennaria scariosa, n. sp.—Cespitose, lightly hoary tomentose throughout: stems 3-6^{cm} high; stolons short, at most 4^{cm} long: leaves 1.4^{cm} long or less, spatulate, obtuse or acutish, inclined to be conduplicate; cauline leaves rather ample, oblanceolate varying to narrowly oblong, occasionally the lowest spatulate: heads 6^{mm} high, sessile, 6-8 in a subcapitate leafy-bracted cluster: bracts (pistillate) rather conspicuously scarious, all obtuse, the scarious portion milk-white, elliptic to obovate.

In its floral character this is very closely allied to *A. arida*, differing only in its broader bracts. *A. scariosa* differs from that species, also, in its smaller size, its more prostrate habit, its larger radical leaves, and in its more ample cauline ones, which are never twisted. It also seems to be related to

A. recurva, as is evident from Dr. Greene's description of that species. It cannot be that species, however, for *A. scariosa* is distinctly cespitose, much resembling *A. aprica* in that respect, and its bracts (pistillate) are decidedly obtuse. Its leaves are also smaller and its stems taller.

Type in Herb. Univ. of Wyo., no. 4587, Leroy, Uinta co., June 7, 1898, by *Aven Nelson.*

ANTENNARIA ROSEA (Eat.) Greene, Pitt. 3:281.— Of this beautiful species there is but one specimen in this collection, secured by Aven Nelson at Dome lake, near the summit of the Big Horn mountains, July 16, 1896, no. 2904.

ANTENNARIA PARVIFOLIA Nutt., Trans. Phil. Soc. 7:408. *Antennaria microphylla* Rydb., Bull. Torr. Bot. Club. 24:303.— This is our commonest Antennaria, met with everywhere in meadows on the high elevated plains of Wyoming. Its distinctive characters have been already pointed out by Dr. Greene. However, from an examination of our rather numerous specimens of this species, the following characters are noticeable. The exceedingly small leaves are covered with a dense lustrous silvery tomentum, and the apices are triangular. The subtending bracts and the one or two uppermost cauline leaves are inclined to be glabrate, and somewhat viscid-glandular. The stems are usually covered with floccose wool. In none of our specimens is there any trace of a pinkish tinge in the pistillate bracts. A dwarf form (no. 3578) with very broad truncate-obtuse staminate bracts, from southwestern Wyoming, is probably very nearly typical. The following are the chief collections of this species: no. 762, Upper Wind River, August 10, 1894; no. 762, Dubois, August 10, 1894; no. 3514, Pine Bluffs, July 6, 1897; no. 3578, North Vermillion creek, July 17, 1897; no. 4846, Freezeout hills, July 10, 1898; no. 4933, Seminole mountains, July 21, 1898; also, by *Miss Clara Sanders* from Little Goose creek, Sheridan county.

Antennaria imbricata, n. sp.— Stems about 30^{cm} high, inclined to be wavy; stolons very short: leaves spatulate, mucronate, 1-nerved, 2^{cm} [illegible] slightly tomentose on both sides; cauline leaves hoary pubescent, [illegible] longer but not broader than those of the stolons, oblong-linear, the margins frequently undulately revolute, the lower slightly broadened upwards, somewhat obtusish and mucronate, the upper narrowed upwards and acute: heads large, about 7^{mm} high, in a close cluster; the pedicels very short, covered with yellowish wool as also the base of the involucres: bracts (pistillate) imbricated, in about four series, pinkish, all more or less serrulate, the outer very broad and obtuse, the innermost narrow and acute.

It differs from *A. parvifolia* in its larger, less silvery leaves, and in its much broader pistillate bracts. From *A. foliacea* it is readily distinguished by its less ample cauline leaves, its much larger heads and its pluriserial bracts.

Type in Herb. Univ. of Wyo., no. 2036, collected in a meadow on North fork of Crow creek in the Laramie hills, July 11, 1896 (*Elias Nelson*).

Antennaria corymbosa, n. sp.—Stems erect, 25^{cm} high, with numerous ascending or assurgent sterile branches at base: leaves thin, sparsely tomentose, 1-nerved or indistinctly 3-nerved, narrowly oblanceolate, tapering gradually into a slender petiole, $3–3.5^{cm}$ long (including petiole); cauline leaves shorter, linear, acuminate: heads small, $4–5^{mm}$ high, in a rather close corymbose cyme, the lowest pedicel usually surpassing the others in length: involucres woolly with cobwebby hairs; bracts (pistillate) in about three series, oblanceolate, obtuse or the innermost acutish, a brown spot above the greenish portion, tips white.

A well marked species, evidently closely related to *A. pedicellata*, from which it differs in its obviously nerved and much less conspicuous leaves. Its woolly, cobwebby involucres and the brown middle portion of its bracts give a characteristic appearance.

Type in Herb. Univ. of Wyo., no. 4160, collected by *Aven Nelson* on a sunny slope at Battle lake in the Sierra Madre mountains, August 15, 1897.

ANTENNARIA RACEMOSA Hook, Fl. Bor. Am 1:330.—This well known species was collected by Aven Nelson in 1894, Union pass, August 1, no. 812.

ANTENNARIA PULCHERRIMA (Hook.) Greene, Pitt. 3:176.—This is common at subalpine stations, growing in rich, loamy soil on wooded hillsides, no. 819, Union pass, August 12, 1894; no. 3225, Green top, June 28, 1897.—ELIAS NELSON, *University of Wyoming, Laramie.*

A NEW COLORADO ANTENNARIA.

THROUGH the kindness of Professor C. S. Crandall it has been possible to examine the specimens of Antennaria in the Herbarium of the Agricultural College of Colorado. This has brought to light a member of the *A. plantaginifolia* group which has not as yet been recognized. Since *A. plantaginifolia* has at last been broken up into well defined species, this one, which offers excellent points of distinction, may be named

Antennaria obovata, n. sp.—Stems 30cm high: stolons 5–8cm long, with very small leaves and only properly leafy terminally: leaves all of firm texture, permanently tomentose on both sides, the tomentum even persisting on the dry leaves of the preceding year; the basal 3cm long, 3-ribbed, the prominent midrib continuous to the apex, the two lateral ones becoming evanescent toward the margin, the blade obovate-cuneate, about 13mm broad, a little longer than the ligulate petiole; the terminal ones of the stolons 25mm long, less distinctly 3-ribbed: cauline leaves small, oblong-linear: heads 3–7, corymbosely disposed on pedicels 5–20mm long: involucres sparingly long woolly: bracts (pistillate) in several series; the outer short and obtusish; the inner twice as long, narrow, acute to acuminate; nearly all with a purplish spot at the middle: akenes oblong-fusiform, indistinctly 5-angled, papillose.

To what is now considered as *A. plantaginifolia* it bears little resemblance, being perhaps more widely separated from that than any of the recently described species of that group. It is from the foothills of Colorado; collected by J. H. Cowan, near Soldier cañon, June 20, 1895.—ELIAS NELSON, *University of Wyoming, Laramie.*

CURRENT LITERATURE.

BOOK REVIEWS.

A new treatise on ecology.

THE impetus to a study of ecology as an integral part of botany, coordinate with morphology and physiology, dates back to Warming's *Ecological plant geography*, published only four years ago.[1] The rapidity with which this new field of study is developing is shown by the large number of special treatises which have appeared since Warming's work. This latest work of Schimper[2] is calculated to lead another great advance, and may be said probably to mark the beginning of a second epoch in the pursuit of ecological investigation.

Schimper, like Warming, is not a narrow specialist, but has made valuable additions to our knowledge in many fields of botanical research. His studies in morphology, cytology, physiology, taxonomy, and ecology have peculiarly fitted him to take up an immense work of this sort in a thoroughly scientific manner. The result of his labors is a volume of nearly 900 pages, a veritable compendium of ecological knowledge, systematized and brought up to date. In the preface the author says that the cue for ecological study was given by the study of plants in extreme conditions, since only there are the effects of environment strongly marked and easily understood. Hence investigations in the tropics, and above all the studies of Haberlandt, Wiesner, and others at Buitenzorg, have given a great impetus to the study of ecology. Schimper appeals for a polar laboratory, so as to study the extreme but relatively simple effects of an arctic environment.

The general divisions of Schimper's *Plant geography* resemble those of Warming. First, the ecological factors are treated; water, heat, light, air soil, animals. Then there is a discussion of formations and associations in general. Over three fourths of the work is taken up with a detailed description of the formations of the various zones and regions, the tropical, temperate, and arctic zones, the mountains and the waters.

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[1] WARMING, EUGEN: Plantesamfund. Grundträk af den ökologiske Plantegeografi. Kjöbenhavn. 1895. See BOT. GAZ. 22: 173. 1896.

[2] SCHIMPER, A. F. W.: Pflanzengeographie auf physiologischer Grundlage. Mit 502 als Tafeln oder in den Text gedruckten Abbildungen in Autotypie, 5 Tafeln in Lichtdruck und 4 geographischen Karten. 8vo. pp. xviii + 876. Jena: Gustav Fischer. 1898. Brosch. *M* 27; geb. *M* 30.

There are several general features in the work which strike one at a glance, and which are highly commendable. There is a wealth of well-chosen illustrations of plant habits and plant formations, largely reproductions of photographs. These pictures are thoroughly representative, and illustrate the leading features of all regions thus far studied. A second highly commendable feature is the persistent correlation of ecological observations on plants in the field with physiological experiments carried on in the same region. Observation and experiment together check erroneous conclusions derived from one alone. Meteorological data and anatomical study also contribute their part to the interpretation of the facts of observation. In every case, Schimper has brought all possible data together in a more systematic and thorough manner than has been previously attempted. Hence, the probability that his conclusions are correct is very great. The bibliographies are remarkably complete and easy to consult because of their topical arrangement.

Another characteristic that will be pleasing to botanists everywhere is the absence of any undue predilection for Germany and German botanists. The work of botanists all over the world is given a proper share of attention. It is gratifying, too, to see the wealth of material furnished from tropical fields, and largely by the author himself. The use of the word ecology in place of biology is a pleasing departure and a deserved tribute to Warming.

Among the new points of view that are presented is Schimper's statement of the relation between plants and water. Hygrophytes are plants that further their transpiration, xerophytes are plants that check it, while the word tropophyte is introduced to include those plants which are hygrophytic at one season and xerophytic at another. According to this view, these terms are placed on a physiological rather than a physical basis. The plant itself, rather than the soil in which it grows, is called hygrophytic or xerophytic.*

Another striking difference from Warming is seen in considering various ecological agents equivalent with water as factors in classification. Thus the simplicity of Warming's classification is replaced by a much greater complexity. This is the common fate of all sciences, as is well illustrated by a comparison of the simple taxonomic system of Linnæus with that of Engler. The great zones of the earth are determined primarily by the distribution of heat, while the great formations of these zones, such as forest, savanna, or desert, are determined chiefly by meteoric water. The local diversities in these great regions are said to be caused by differences in the soil. Thus we have two great types of formations: (1) climatic formations which characterize great regions and are caused by climatic factors, and (2) edaphic (from ἔδαφος, soil) formations, which make up the local variations in any district and are due to a local dominance of edaphic over climatic influences. Schimper also lays much greater stress than does Warming upon the influence of light, heat, atmospheric density, and the chemical nature of the soil, in shaping the character of the vegetation.

It seems unfortunate to the reviewer that more attention was not paid to what may be called, speaking broadly, the geological relation. The short section on the transformation of edaphic to climatic formations is excellent and might well be much enlarged. In order to understand any formation it is necessary to know its history, and this history can be interpreted only by the most painstaking study of areas in which transitions from edaphic to climatic formations are now taking place. With this study there must be coupled a study of the physiographic history of the region. The study of the cumulative influence of past environments, the lagging of effects behind their causes, is still in its infancy. Perhaps it is because of our lack of knowledge along these lines that Schimper's great work deals so much more with static than with developmental ecology.

This new treatise is a distinct addition to our knowledge, both as a compendium of previously stated but scattered facts, and as a source of many new details and better points of view. Of course all ecologists must have it and must be familiar with its contents from cover to cover. This new volume is certain to stand always as one of the great botanical masterpieces. — HENRY C. COWLES.

Economic botany.

ONE of the best works yet written upon cultivated plants has just been published by Dr. R. Sadebeck.[3] While the title might suggest that the subject matter would attract only those especially interested in the plants of the German colonies, this is not at all true, since these plants are discussed so comprehensively that their relations to dissimilar as well as similar economic plants of other regions are constantly suggested. After having given a careful description of the taxonomic features of a plant, the author discusses its culture, its native region and its distribution, the varieties produced under cultivation, its useful products and the way in which these are utilized as foods, medicines, or in industrial arts. Photographs and drawings, almost all of which were especially made to illustrate this work, appear in abundance. These illustrations, while having to do almost entirely with taxonomic features, are so excellent that they constitute one of the most pleasing and satisfactory parts of the book.

In the first chapter the author discusses the palms. At least thirteen genera are grown in the African colonies, producing large quantities of food material for local consumption and for commerce. Several of these also supply important textile materials and all are prominent features of the landscape. Another chapter is devoted to the description, cultivation, and preparation of tobacco for use. This is the most widely cultivated plant of the German colonies, being grown everywhere. Only the species *N. Tabacum* is extensively grown, *N. rustica*, which is so common in some other tropical countries, being scarcely known. The fungus parasites which induce diseases of this plant are numerous, and the way in which they affect the plant is equally varied. At the close of this chapter is appended a bibliography of the most important literature upon the subject. Many readers will regret that a similar appendix is not to be found with the other subjects.

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[3] SADEBECK, R.: Die Kulturgewächse der deutschen Kolonien und ihre Erzeugnisse. 8vo. pp. xiii + 366. *figs. 127.* Jena: Gustav Fischer. 1898, Brosch. *M* 10, geb. *M* 11.

The other twelve chapters of the book are not arranged with reference to any particular genus or group of plants, but with reference to certain economic products, as "Grains and sugars," "Edible fruits and vegetables," and "Eigentliche Genussmittel"—the coffee and tea group. The colonies produce many of the spices, and the number of plants yielding fats and oils is no less. Indigo, gums, caoutchouc, and gutta-percha are prominent among the products of the colonies. Twenty plants yield textile materials or useful woods. The number of medicinal plants grown is very small, and comparatively little space is given to the chapter which deals with these.

It is obviously the author's intention to deal merely with that part of economic botany which has to do with the useful plants; and those unfamiliar with this subject will be surprised to find that there are so many of these. Dr. Sadebeck expresses the belief that should the people of the German colonies, through the medium of such a book as he has written, become informed of the possibilities, the product from these plants, at present not large, would be very greatly increased. A comparison of the unused regions with those in which these plants are now grown shows that the cultivation has scarcely begun. The book is full of information and is worthy of the attention of every one interested in the inter-relationships of men and plants.—OTIS W CALDWELL.

The making of a daisy.[4]

TO POPULARIZE science is a worthy purpose, and it should be undertaken more by those who represent it. As the reviewer understands it, to popularize is to present the important facts in simple language, free from technicalities and with clear illustrations, in an attractive style, but never at the expense of accuracy. Judged by such a definition the book before us cannot be called a success, but it is a good type of its class. The author is well informed, but her contact with plants seems to be sentimental rather than scientific. To cultivate a sentimental affection for nature is delightful, but it should never be labeled science.

Certain facts about plants are taken, and most fanciful, not to say dreamy, hypotheses are developed. For example, "the making of a daisy" is presented as "a study in evolution," and the processes involved, from "the beautiful, flowerless fern-trees and gigantic mosses," where "the arrangements for reproduction are so complicated that it is almost impossible for any person to understand them" (as presumably they do in seed plants), to the daisy, are something that would amaze the morphologist. "Looking carefully amongst the fronds of some palm-like fern," the author fancies that she "might have discovered two small objects," "the one had a yellow, powdery head, whilst the surface of the other was more or less sticky." These "small objects" discovered in imagination on an ancient tree fern are "a single stamen and a single naked ovule," the "first parents of the flowers." It is this sort of wild imagination that seems to the reviewer to do more harm than good.

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[4] HUGHES-GIBB, ELEANOR: The making of a daisy; "wheat out of lilies;" and other studies in plant-life and evolution. A popular introduction to botany. 8vo. pp. [illegible] Charles Griffin & Co.: London, 1898.

There is a constant outcry throughout the book against the "hard words" of the science, but in the chapter on the "relationship of the flowers," the pages fairly bristle with the old morphology in reference to "cohesion," "adhesion," "suppression," etc., and such group names as "Dichlamydeæ," "Thalamifloræ," "Calycifloræ," etc.

It should be understood that the reviewer makes no objection to the book as a piece of sentimental literature, but as "a popular introduction to botany" he must protest against it.— J. M. C.

California plants.[5]

MRS. DAVIDSON has certainly done good service for nature study in southern California, and has given a model for similar books in other regions. She does not seek to arouse a factitious interest in plants by "fairy tales," but in a very attractive style tells of the most evident things that can be observed. The book cannot be used without a study of the living plants, in cultivation or in the field, which is much in its favor. It is a storehouse of suggested observations when in contact with the material. And the material selected is what the author has found to be most available in her long experience in southern California. "The aim is to awaken interest in common plants, and to invest them with new meaning. Pond-scums, mould, and toadstools are included among these familiar plants, and sea-mosses, lichens, and ferns are believed to be as attractive as flowering plants."

A voluminous supplement takes up each chapter and gives full suggestions to teachers. Evidently the author's experience has shown to her how much they need it. It is a pleasure to commend a book prepared for nature study, a book which does not leave its few facts to spin out endless fancies, but which goes directly and soberly out among the plants of the neighborhood and calls attention to what can be observed.— J. M. C.

[5] DAVIDSON, ALICE MERRITT: California plants in their homes. A botanical reader for children. 8vo. pp. 133. B. R. Baumgardt & Co.: Los Angeles, Cal., [illegible]

The evolution of plants.[6]

Books of this kind are exceedingly useful, and there should be more of them. It is hard for one who is not a professional botanist to get from ordinary text-books much idea of the evolution of plants as a whole. The worst of it is that those who know little or nothing of modern morphology have written most in a popular way about the evolution of plants, and have propagated fanciful notions which are hard to eradicate.

The basis of this little volume is a course of lectures given at Stanford University, and its purpose is to organize well-known botanical material to illustrate the probable lines of evolution. The book will demand some elementary knowledge of plant groups, but it is probably as simple as the subject will permit. There is no presentation of new theories or discussion of old ones for the benefit of the professional botanist, but merely a statement of current views. Undoubtedly exception will be taken to certain views of homology and phylogeny, but this is to be expected whenever difference of opinion is possible.

It is of interest to the professional botanist to note the author's opinions as to phylogeny, many of them of course very cautiously expressed. Leaving aside the myxomycete and schizophyte forms as altogether problematical, the green algæ, considered the most primitive of the three classes of algæ, are regarded as having arisen probably from simple Volvox-like types, the Volvox, Protococcus, and Conferva forms representing a continuous series leading to the higher plants. From this stock the Siphoneæ, Conjugatæ, Rhodophyceæ, and possibly the Characeæ, have arisen as offshoots. It is suggested that the brown algæ may have had an independent origin. The origin of the liverworts from the green algæ, and that of the pteridophytes from Anthoceros-like liverworts is still maintained. In reference to the seed plants, the conifers are regarded as phylogenetically related to the club-mosses; while the cycads and angiosperms are referred to the ferns. Two lines of dicotyls are represented as having arisen from the monocotyls, one from the aroid forms, leading through peppers to amentaceous and syncarpous sympetalous forms; the other from apocarpous monocotyls and leading to the anisocarpous sympetalous forms, and culminating in the Compositæ.

The book is full of interest and suggestion, and commends itself not only to those who wish a reading knowledge of botany, but also to teachers of botany.—J. M. C.

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[6] Campbell, Douglas Houghton: Lectures on the evolution of plants. 8vo. pp. x + 319. The Macmillan Company: New York. 1899. $1.25.

MINOR NOTICES.

DR. H. E. HASSE has issued a second edition of his *Lichens of Southern California*. It is reprinted, and unfortunately repaged, from the *Proceedings* of the Southern California Academy. When will authors and publishers learn that a repaged separate is thereby mischievously removed from its proper place in literature and made a source of annoyance whenever occasion arises for citing it? The list itself is useful and the work praiseworthy.—C. R. B.

THE SECOND FASCICLE[7] of Dr. M. Gürke's continuation of Richter's *Plantæ Europææ* has just appeared. The first fascicle has been reviewed in this journal (**24**: 122. 1897), and no further explanation is needed as to the occasion and method of the work. The first fascicle presented the Archichlamydeæ from Juglandaceæ to Chenopodiaceæ; the present fascicle continues through Caryophyllaceæ, in fact most of the fascicle is given to this family.—J. M. C.

THE DEPARTMENT OF AGRICULTURE is prompt to take charge of our new domain. Hardly had Hawaii and Puerto Rico come into the possession of the United States before a bulletin (no. 21) on vanilla culture appeared from the Division of Botany, prepared by S. J. Galbraith, a planter in the Seychelles islands, where vanilla is extensively cultivated. It is hoped that both Hawaii and Puerto Rico will be found to furnish suitable conditions for this profitable industry, but warning is given that a very destructive parasitic fungus may accompany the introduced plants unless carefully examined by an expert.—J. M. C.

THE WRITINGS of Professor Beal are well known, and also the service he has rendered to the teaching of botany. His recent little book, entitled "Seed Dispersal,"[8] is intended to help "young botanists and teachers," and deals with one of the most attractive of botanical subjects. The title is a little misleading, as the book takes a wider range than seed dispersal. For example, vegetative propagation, spore dispersal, and plant migration are all discussed. The author writes in a pleasant, conversational style, and the book should serve its purpose well. The sketches are original, and deal with common plants.—J. M. C.

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[7] GÜRKE, DR. M. Plantæ Europææ. Enumeratio systematica et synonymica plantarum phanerogamicarum in Europa sponte crescentium vel mere inquilinarum. Operis a Dr. K. Richter incepti. Tomus II. Fasc. ii. 8vo. pp. 161–320. Leipzig: Wilhelm Engelmann, 1899. *M* 5.

[8] BEAL, W. J. Seed dispersal. 8vo. pp. vii + 87. Ginn & Co. Boston. 1898.

NOTES FOR STUDENTS.

[At the request of the editors Dr. Otto Kuntze has kindly prepared the following brief synopsis of his most recent volume.[9] — EDITORS.]

THE FIRST PAGES (1–384) in the body of the work contain the list of plants collected in Patagonia, Argentine, Chili, Bolivia, Paraguay, Brazil, and also during the author's travels in South Africa. There are described 11 new genera, 18 new subgenera, 566 new species, and more than 600 new varieties. The minor part of the collections was studied by thirty-two collaborators, and 6 new genera and 179 new species have been previously published.

The change in the generic names of phanerogams, according to the Paris Code, are very few, as they were revised in 1891 in volumes I and II.

For the algæ, however, a change of 36 generic names is proposed, and those made in 1891 are mostly defended against the criticisms of M. Le Jolis, who has opposed with the following ideas: (1) that priority be not retroactive; but the Paris Code excludes only names before Linnaeus; (2) that adjectives cannot be used for generic names; but hundreds of such names already exist; (3) that unfit names be rejected; but A. de Candolle has already written "un nom est un nom," and a name needs no meaning at all; (4) that an author be allowed to change his first definition of a genus and its name; but according to § 59 and its official commentary the first definition cannot be annulled; (5) he confounds obligatory and optional articles of the Code; (6) he rejects orthographical license and corrections, although allowed by the Code; (7) he allows only diagnoses for genera to be valid, against § 42 of the Code. His follower, M. Malinvaud, secretary of the Société botanique de France, has failed to make the necessary preparation for a Paris Congress in 1900 to amend the Paris Code of 1867.

As to fungi, I had shown formerly that in Saccardo's *Sylloge* 570 names of genera are entirely omitted. In proving them I have been compelled to renew 111 more generic names in *Revisio* III^{ii} than in *Revisio* I and II. I also show that it is impossible to begin the nomenclature of fungi with a later starting point.

In pp. 1–202 of the Introduction I trace the movement in nomenclature from 1893 to 1898, but can report little of it here. However, some American positions may be mentioned. There are now two extreme parties of botanical systematists in the United States.

1. *The old party*, represented by Dr. Robinson, etc., follows no real principle at all, and has only one rule for genera.

"Long established and generally known generic names, such as Liatris, Desmodium, Dalea, Calycanthus, Carya, Aspidium, and others should be retained. While the scope of this rule is left to the discretion of writers, it is urged that generic nomenclature should not at present depart far from that of the three important works, Bentham and Hooker's *Genera Plantarum*, Baillon's *Histoire des Plantes*, and Engler and Prantl's *Natürliche Pflanzenfamilien*, from which for some time to come our most complete and accurate information as to generic limits and affinities is to be derived."

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[9] KUNTZE, OTTO: Revisio generum, etc., III^{ii}. 8vo. pp. 784. New York: G. E. Stechert. September 1898. $7.

I have answered this in *Revisio* III^{II} as follows: A rule which is left to the discretion of any botanist is no rule at all. The differences between (1) Baillon's *Histoire des Plantes*, who after 1891 accepted 70 per cent. of my nomenclature, reformed according to the Paris Code; (2) Bentham and Hooker's *Genera Plantarum;* (3) the disorderly nomenclature in 10 volumes of Engler and Prantl's *Pflanzenfamilien* by 62 collaborators; and (4) Engler's Supplementary nomenclature, corrected according to his rules, illustrate without further discussion the results of the method suggested. The numerous differences in nomenclature can only be removed by fixed rules, which are also necessary in consequence of the complications arising from competing generic homonyms. Order in nomenclature can only be restored by a consistent application of the rules of the Paris Code, which were adopted by the only international convention that has been held.

2. *The Check List party*, led by Professor Britton and others, with three very wrong principles: (1) 1753 as a starting point, (2) priority of place, (3) once a synonym, etc., applied retroactively.

The initial date, 1753, was originally a Kew proposition, and became fixed like the other "Kew rule," which allows the arbitrary rejection of the oldest specific name. This starting point was hastily adopted by the incompetent Genoa Congress which was "mal informe" as Professor Briquet wrote, who preferred the De Candollian starting point of 1737. It was only supposed, not proved, that 1753 is a rational starting point. But this date for genera is neither scientific, because 1753 is without genera diagnoses, nor is it economical. I have proved in *Revisio* III^{ii}, by a list of examples, that [illegible] more genera and 7100 more species are to be named with 1753 as a starting point than with 1737. Only 29 of these genera and 152 of these species have been named until now, although I had given in 1893 (*Revisio* III) a similar list. That the 1753 rule should be abandoned is effectively shown by the fact that according to it about 100 genera and 6000 species still await renaming. I have also given a list of 64 genera which must be renamed according to either starting point, and another list of 46 other generic names which would be substituted for without profit. Formerly, I called 1753 for genera "initium ignorantium," but now, since its eminent harmfulness has been demonstrated, it becomes the "initium stupidorum" for those who maintain it and are not able to prove the contrary.

The priority of place principle has been applied until now to only genera containing 74 named species, as against its abandonment for 23 genera containing 7310 species. This principle was applied in the manuscript of the Torrey *Check List* and sanctioned at the Madison meeting of 1893, five days before the Madison Botanical Congress. But in the *Check List*, as afterwards printed, this wrong principle was mostly eluded by separating in the Appendix, Blitum from Chenopodium, Sarothra from Hypericum, as also formerly Dalibarda from Rubus, Phaca from Astragalus, etc., to avoid the change of the thousands of specific names belonging to these genera. Thus the wrong principle was not applied, but resulted in bad taxonomy.

The principle "once a synonym always a synonym" was recommended by me only for future cases in which new names were necessary. If it is applied retroactively, however, it is very harmful, as I showed in 1894 in "Nomenclatur Studien" (*Bull. Boiss.* 477–481), and now in *Revisio* III$^{\text{II}}$. I show that with the retroactive use of this principle 447 generic names and 16,000 specific names of phanerogams are still to be changed; while only 34 generic and 134 specific names were changed until now by this principle. Since the harmfulness of the retroactive application is so evident, why not frankly abandon it?

Chapter 26 begins with the title "Engler's international breach of faith." He was the enterprising director of the deceased international commission of botanic nomenclature. He put aside the chairman of the commission, Professor P. Ascherson, in 1897, and with the aid of Professor K. Schumann produced fourteen new rules of nomenclature for his *Pflanzenfamilien*, baffling thereby any international congress, although under international obligation. Of these fourteen rules, thirteen were scarcely applicable and merely garniture to the second rule, which proposes to bar generic names that have not come into general use during fifty years, counting from their publication, unless they were taken up in a monograph or large flora, according to the laws of nomenclature of 1867. This ambiguous rule, of little profit, had already been declined in 1894 in Vienna by the Naturforscherversammlung, with the suggestion that it be approved by a competent congress. This rule was unfairly applied only in the supplement to Engler's *Pflanzenfamilien*, otherwise the editor would have been compelled to accept most of the reformed nomenclature of *Revisio* I and II. These fourteen rules were subscribed to by the officers of the Berlin Botanic Museum in a very careless manner, as is also shown by the "ich" of the editor, which "ich" remained uncorrected in these rules, although subscribed to by fourteen persons. They had never considered beforehand and together these rules, which have been more or less declined by Professor Wettstein (Prag), Professor N. L. Britton (New York), Le Jolis (Cherbourg), Briquet (Geneva), James Britten (London), and E. Heirn, who has written in *Journal of Botany* (27 : 494. 1898) and I criticised these rules in *Revisio* III$^{\text{ii}}$ in a masterly way, and rejected the second rule with powerful arguments. In a list (pp. 100–125) I show that 618 of my reformed generic names among the phanerogams, out of 740 in *Revisio* I and II, have been already accepted since 1891 by botanists all over the world, or that some of the names not yet accepted could not be rejected by the Berlin rules.

In pp. 40–42 I sum up the obscurities of the Kew Index. In chapter 3 I add further notes to Pritzel's *Thesaurus*, with exact dates for wrong or unknown dates of publication.

Since a competent international congress at Paris in 1900 is not possible, and the amendment of the Paris Code will scarcely be obtained for a long time, the only way to obtain international order in botanical nomenclature is by strictly following the Paris Code with my amendments, which are not at all revolutionary. But since the starting point 1735 has found everywhere least acceptance, it will be best to take the only really scientific and the most economical starting point of 1737.—DR. OTTO KUNTZE, *Villa Girola, San Remo, Italy.*

ITEMS OF TAXONOMIC INTEREST are as follows: A fascicle of eighteen new species of Lower Californian plants is published by T. S. BRANDEGEE in *Erythea* (7 : 1–9. 1899).—A new Botrychium from New England (*B. tenebrosum*) is published by A. A. EATON in *The Fern Bulletin* (7 : 7. 1899).—In the *Bull. Torr. Bot. Club* (**25** : 605–621. 1898) JOHN K. SMALL continues his "Studies in the botany of the southeastern United States." Twenty-four new species are described as follows: Melanthium (1), Smilax (4), Gyrostachys (3), Oxalis (2), Physostegia (1), Euphorbia (4), Hypericum (1), Gaura (1), Verbena (1), Gerardia (2), Solidago (1), Doellingeria (1), Aster (1). The author's name *Forcipella* for a genus of the Paronychiaceæ having been preempted, he has replaced it by *Gibbesia*, in honor of Professor L. R. Gibbes, of Charleston, S. C.—In the same journal (626–6[illegible]) A. A. HELLER publishes further notes concerning the plants of western North America. A new genus, *Fendlerella*, is proposed, established on *Fendlera* (§ FENDLERELLA) *Utahensis* Greene (*Whipplea Utahensis* Watson); and another new genus, *Macdougalia*, is established on *Actinella Bigelovii* Gray.—In the same journal (**26** : 5–11. 1899) AVEN NELSON publishes ten new species of Wyoming plants in the following genera: Scirpus, Sagittaria, Lilium, Abronia, Arenaria, Aconitum, Astragalus (4 spp.).—H. N[illegible] in the same journal (**26** : 21–22. *pl. 351.* 1899), describes a new Lacinaria (Liatris) from Texas.—E. L. GREENE has just published (*Pittonia* 4 : [illegible] 1899) four new species of Castilleia from the west, and a fascicle of seven new violets; has renamed *Viola bicolor* Pursh, calling it *V. Rafinesquii*; has described five new western roses, one of which (*R. pratinicola*) is the common prairie form commonly referred to *R. Arkansana* or *R. blanda*; has established fourteen new species of western "choripetalous exogens" [illegible] following genera: Aquilegia, Ranunculus (2 spp.), Cleome, Draba (7 spp.) Thelypodium, Amelanchier (2 spp.); and has published notes on seven species of Machæranthera, two of which are new. — B. L. ROBINSON has described and figured (*Rhodora* **1** : 12. 1899) a new Lactuca (*L. Morssii*) from Massachusetts. – In Engler's *Bot. Jahrb.* (**25** : 578–708. 1898) F. REINECKE completes his account of the flora of the Samoan islands. In a previous paper (**23** : 237–368. 1896) the cryptogams were given; in this paper the "siphonogams" are presented, and also a complete species index to both papers. The total enumeration contains something over 1200 species, 141 of which are new. — In the same serial (709–721) R. PILGER describes thirty-one new species of South American (Columbia, Ecuador, Peru, and Bolivia) grasses, one of them representing a new genus, *Dasypoa*. — In the same serial (722–733) a series of papers upon the plants of Ecuador is begun, the families being assigned to different authors. Numerous new species are described, especially by K. Schumann, among the Asclepiadaceæ, six species being added to Cynanchum, and a new genus, *Anomotassa*, described. — In the same serial (**26** : 235–424. 1899) A. ENGLER continues the publication of the African flora. The Passifloraceæ, Araliaceæ, and Leguminosæ II (new genus *Fillæopsis*) are by H. Harms; Euphorbiaceæ IV (new genera *Crotonogynopsis* and *Tetracarpidium*) by F. Pax; Orchidaceæ by R. Schlechter; a new genus (*Megalochlamys*) of Acanthaceæ by G. Lindau; the African species of Brunnichia by U. Dammer; a new genus (*Charadrophila*) by R. Marloth, which possibly belongs to the Gesneriaceæ; Piperaceæ II by C. De Candolle; Piperaceæ III, Gesneriaceæ III (new genus *Carolofritschia*), Burseraceæ II (new genera *Canariastrum* and *Porphyranthus*), Rosaceæ II, Monimiaceæ (new genus *Chloropatane*), Lauraceæ (new genus *Tylostemon*), Menispermaceæ (new genera *Miersiophyton*, *Kolobopetalum*, *Syntriandrium*, *Limaciopsis*, and *Heptacyclum*), Araceæ II, all by A. ENGLER. — In the same serial P. GRAEBNER (425–436) discusses the South and Central American species of Valeriana, suggesting *Phaodendron* as a new section or possibly a new genus; and F. KRÄNZLIN (437–448) begins an account of the Orchidaceæ collected by Lehmann in Guatemala, Costa Rica, Columbia, and Ecuador. — MAXWELL T. MASTERS has determined (*Jour. Bot.* 37 : 1–11. 1899) that the juniper of Bermuda and that of Jamaica are specifically distinct, and that the latter is *J. Virginiana* L. (*J. Barbadensis* L. ex Griseb.), so extensively distributed throughout North America. The Bermudan plant (*J. Bermudiana*) is only known outside of Bermuda in cultivation, and seems to have been derived from the continental *J. Virginiana*. Why a form in Bermuda should have become specifically distinct, and one in Jamaica should have retained its specific characters, is an interesting question. — Another contribution to the African flora is a study of the genus *Boscia* by ANTON PESTALOZZI, being one of a series of papers published from the Botanical Museum of the University of Zürich. The taxonomic presentation is preceded by an excellent account of the morphology and anatomy of the genus. The twenty-nine species, five of which are new, are treated with remarkable fullness, an average of four pages being given to each one. Fourteen excellent lithographic plates, some of them colored, accompany the paper.— R. I. CRATTY in *Bull. Lab. Nat. Hist. Iowa* (**4**: 313–375. *pls. 10.* 1898) has published a list of Iowa sedges, with synonymy and distribution. It contains 114 species and varieties, representing ten genera, Carex containing 78. Following the list are some interesting tables comparing the Iowa sedge flora with that of neighboring states. — W. N. SUKSDORF has published in *Deutsche bot. Monatsschrift* (**16**: 220–222. 1898) an account of certain Washington species of Claytonia, which he refers to Montia and renames. — An enumeration of the species of plants collected by Dr. W. C. Shannon in Central America in connection with the survey of the Intercontinental Railway Commission has been published by JOHN DONNELL SMITH (Intercont. Railway Com. **1**: part 2. appendix 3. pp. 1–24. 1898. Washington.) — J. M. C.

MR. V. H. BLACKMAN, in his study of *Pinus sylvestris*[10] has made an important contribution to our knowledge of the subject of fertilization. Beginning with the formation of the ventral canal cell, the processes are traced with considerable detail up to the early stages in the formation of the sporophyte. During the great increase in size which the oosphere nucleus undergoes previous to fertilization, it becomes filled with a metaplasmic substance, at first granular, but in later stages taking the form of an elaborate reticulum, which might easily be mistaken for chromatin. The true chromatin, however, consists of a few small, rod-shaped masses.

The entire contents of the end of the pollen tube pass into the oosphere. The four nuclei are plainly visible as they enter the egg, but it is impossible to distinguish the stalk nucleus from the tube nucleus. As the sex nuclei come into contact, they are seen to contain numerous kinoplasmic threads which the writer regards as the beginning of the first segmentation spindle. The two groups of chromosomes, belonging respectively to the male and female nuclei, can be distinguished after the nuclear fusion is complete, and even after the first segmentation spindle is nearly formed ; in fact, the chromosomes were observed to undergo longitudinal splitting while the two groups were still distinct. According to all previous accounts of fertilization, the fusion nucleus enters a resting stage before segmentation begins. Since this paper was written Berlese has given a similar account of Peronospora.

The structure of the cytoplasm of the egg and the development and fate of achromatic figure, led to the conclusion that there is no specific kinoplasmic or archoplasmic substance, but that the fibers result from a rearrangement of the ordinary cytoplasmic reticulum.

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[10] On the cytological features of fertilization and related phenomena in Pinus sylvestris. Phil. Trans. Royal Soc. London **190**: 395–426. 1898.

Blackman was not able to confirm Dixon's observations on the number of chromosomes. Dixon reported eight chromosomes in the nuclei of young embryo-sacs, eight in the nucleus of the oosphere, usually twelve but sometimes eight or twenty-four in the nuclei of the cells sheathing the oosphere. Dixon was not able to make a direct count of the chromosomes in the oosphere nucleus, but inferred the number from counting bodies in the nucleus of the ventral canal cell, which may have been disorganized chromatin and not normal chromosomes. Blackman's work, which was much more extensive, shows the number of chromosomes in the various nuclei to be as follows: In the egg, twelve; in pollen mother cells, twelve; nuclei of the female gametophyte, twelve; first division after fertilization, twenty-four; later divisions, over twenty-one and presumably twenty-four.

On account of recent work on Gingko, Cycas, and Zamia, a careful search was made for traces of cilia, blepharoplasts and centrosomes, but no such structures could be found, and the evidence furnished by Pinus was believed to bear out the conclusions of the various writers of the Bonn school against the presence of centrospheres in plants higher than mosses. — CHARLES J. CHAMBERLAIN.

PROFESSOR W. F. GANONG has published in the *Annals of Botany* (**12**: 423–474. 1898) further results of his investigation of the Cactaceæ, giving an account of the comparative morphology of the embryos and seedlings. The group is so modern and so plastic that the author anticipates that the phylogeny of its genera and species may be discovered with remarkable completeness.

As a result of the numerous germination experiments, some interesting conclusions are reached. Beginning with Pereskia, and passing by way of Cereus and Echinocactus to Mamillaria, the author calls attention to a progressive condensation in bulk of the germinated embryos, and consequent diminution of surface brought about by the increasing approach to a spherical form of the hypocotyl and diminution of the cotyledons. This progressive condensation of the embryos runs parallel with the condensation in the adults, but lags behind it, so that adult and embryo do not always correspond. The explanation suggested is that as the adult acquires a certain adaptive character, and it becomes more fixed and intensified, it tends to work back into earlier and earlier stages in the ontogeny of the successive individuals, until it finally reaches the embryo.

A phylogeny of the genera is constructed, based upon these recent observations, together with previously recorded facts. Neglecting the numerous genera which are not represented in our flora, and which for the most part are lines of secondary importance, the main points of the proposed phylogeny are as follows: Pereskia is regarded as nearest to the original stem-form of the family, and the earliest derived line was Opuntia. From the primitive

Opuntia forms the columnar Cereus line was derived, with its numerous generic branches and diverse habits. Low down upon the columnar Cereus line the Echinocactus line branched out, which gave rise later to Mamillaria, and still later to Anhalonium. — J. M. C.

A REDUCTION DIVISION of the chromosomes (in Weissmann's sense) is supposed by most botanists not to occur in plants. Guignard, Strasburger,[11] Sargant, Mottier, and many others find a longitudinal division of the chromosomes, and, consequently, only a numerical reduction. Schaffner finds a transverse division, and, consequently, a qualitative division (reduction division) in the first division in the embryo-sac of *Lilium*; Belajeff believes that a reduction division takes place in the second division of pollen mother cells. Calkins finds a reduction division in the second division of the spore mother cells of ferns.

A recent paper by W. C. Stevens[12] deals with the chromosome problem in ferns. *Scolopendrium vulgare*, *Cystopteris fragilis*, and *Pteris aquilina* were investigated. The writer's summary is about as follows: In the first division of the spore mother cell the spirem thread splits longitudinally and then segments into one half the usual number of chromosomes. The daughter chromosomes are short and thick, and in their form resemble tetrads, but there is no transverse division. The daughter chromosomes begin to separate sometimes at the ends and sometimes in the middle, thus forming double rods or ring-shaped chromosomes. In the daughter nuclei the chromosomes unite into a single nuclear thread. In the second division this thread splits longitudinally and segments transversely, as in the first division. It follows that there is merely a reduction in the number of chromosomes, and not a reduction division. Calkins's figures lack important stages and do not prove a reduction division. A thorough search failed to reveal centrosomes or multipolar spindles. — CHARLES J. CHAMBERLAIN.

FORESTRY IN MINNESOTA, by Professor Samuel B. Green, published by the Minnesota Forestry Association, has been recently issued. It is neatly bound and well illustrated, and contains a good glossary and index, small details that greatly enhance the value of a most useful book. Professor Green has here brought together his class lectures, and they show him to be a thoroughly practical instructor. The little book contains just what the intending planter and the forest land owner need to know. The theory of tree growth is sketched, but the book is full of good practical suggestions such useful and unfamiliar facts as the time of seeding, the treatment of forest tree seeds, the management of the forest nursery, planting, pruning, forest management, etc. With these, which are evidently based on experience, are full descriptions of the trees of Minnesota. It will prove valuable far beyond the limits of Minnesota. — **CHARLES A. KEFFER.**

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[11] Strasburger and Mottier reported a transverse division in pollen mother-cells, but almost immediately acknowledged that their conclusion needed revision. BOT. GAZ. 26: 220–221. 1898.

[12] Ueber Chromosomentheilung bei der Sporenbildung der Farne. Ber. d. deutsch bot. Gesell. 16: 261–265. 1898.

THE WORK of Rimbach on geophilous plants has been previously alluded to.[13] He has recently published a contribution on the growth of rhizomes in depth.[14] Rhizomes have a so-called normal depth, varying with the species. Rimbach's experiments show that a removal of the soil from over a rhizome causes a downward growth, while a deep burial causes upward growth. These results are commonly brought about by a change in the direction of the rhizome axis, though sometimes by root contraction. Since these changes do not take place until some organ of the plant reaches the surface, the author thinks that they are caused by a greater or less need for structural materials on the part of the plant. — **H. C. COWLES.**

E. OVERTON makes a preliminary announcement[15] of a forthcoming paper on some experimental work on autumnal coloration. This much-vexed subject has long needed careful physiological investigation. He thinks that the red coloring matters of plants are probably glucosides, and in most cases [illegible] of tannin compounds with sugar. The chief physical factors involved are sunshine, which augments sugar production, and low temperature, which prevents the conversion of sugar into starch. The replacement of starch by sugar in autumn and winter leaves had previously been shown by Lidforss.[16] Overton found that red tints could be produced in many leaves at any season by feeding them with glucose. — **H. C. COWLES.**

DR. GEORGE BITTER[17] has made some extended observations on the contact relationship of growing crustose and foliose lichens. The relationship is said to be mostly of a saprophytic nature. In some instances contact lines vanish entirely, as when different individuals of *Variolaria globulifera* meet. Growth contact of different species may result in a complete or partial destruction of the less resisting species. In some instances the contact phenomena partake of the nature of parasitism (antagonistic symbiosis). The view is expressed that lichens take but comparatively little nourishment from the substratum. The principal function of the substratum seems to be that of a support. The author also refers to several fungi which are not generally recognized as lichens, namely, *Karschia* (*Buellia*) *scabrosa* and *Lecidea intumescens*.— A. SCHNEIDER.

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[13] BOT. GAZ. 23: 478. 1897.

[14] Beitrage zur wiss. Bot. 3: 177-204. 1898.

[15] Nature 59: 296. Jan. 1899.

[16] Bot. Cent. 68: 33-44. 1896.

[17] Ueber das Verhalten der Krustenflechten beim Zusammentreffen ihrer Ränder. Jahrb. f. wiss. Bot. 33: 47-127. *figs. 1-14.* 1898.

IN A review of recent researches on the spermatozoids, Zacharias expresses himself thus on the centrosome question:[18]

"However, on an unprejudiced consideration of the literature involved, one may consider it not impossible that, on renewed search, the centrosomes will finally be again discovered where, for the present, they have been missed."— C. R. B.

DR. H. VON SCHRENK has been studying the mode of dissemination of *Usnea barbata*,[19] and finds that the wind is the chief agent of transfer. The long strands are broken and carried from tree to tree, and owing to hydroscopic movements the transported strands may soon become entangled with the new host. A similar study of *Ramalina reticulata*, by Peirce, was published in the BOTANICAL GAZETTE (**25**: 404. 1898).— J. M. C.

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[18] Bot. Zeit. $\mathbf{57}^2$: 6. 1899.

[19] Trans. Acad. Sci. St. Louis **8**: 189–198. 1898.

NEWS.

Mr. J. W. Blankinship has been appointed professor of botany in the Agricultural College of Montana.

Dr. Domenico Saccardo, assistant in botany in the university of Bologna, has been advanced to the professorship there.

Dr. Johannes Behrens, bacteriologist, of Carlsruhe, has been appointed to a position under the Imperial Sanitary Bureau at Berlin.

The Berlin Academy of Sciences has made a grant of 2400 marks toward the expenses of a botanical expedition to Java by Dr. Paul Knuth.—*Science.*

Dr. E. B. Copeland has been appointed professor of biology in the State Normal School at Chico, California, and began his duties there about February first.

Cohn's *Beiträge zur Biologie der Pflanzen* is to be continued under the direction of Professor Dr. Oscar Brefeld, the successor of Cohn at the University of Breslau. The first part of the eighth volume has recently been published.

A portrait of the late Professor Teodoro Caruel, for twenty-two years the director of the *Nuovo Giornale Botanico Italiano*, forms the frontispiece of the sixth volume of that journal. In the *Bulletino della Societa Botanica Italiana* 1898: 264 a list of the writings of this eminent botanist is given. The titles number 144.

The fourth annual meeting of the Vermont Botanical Club was held on Friday and Saturday, January 27 and 28, 1899, in Williams Science Hall, of the University of Vermont, at Burlington. The program included a large number of papers, mostly relating to the Vermont flora. The Club seems to be vigorous, enrolling almost 100 members.

The publisher of *American Gardening* announces March 1 an offer of prizes of $75, $50, and $25 respectively, for the best papers on hybridization of not less than 1000 nor more than 5000 words, to be presented before [illegible] 15, 1899. The brevity of both time and space allotted make practically impossible any thorough discussion of this large subject.

On the occasion of the retirement of Mr. J. G. Baker from the post of curator of the herbarium at Kew, his old colleagues, the members of the staff, presented him with an address expressive of their affectionate regret. A representation of the elegant bromeliad called *Bakeria tillandsioides*, drawn by Miss Smith, the botanical artist, served to frame the address.—*Gardeners' Chronicle* III. 25:74.

A FIRE which broke out in the physical laboratory on the night of December 25 destroyed the buildings of the University of Geneva, and with them botanical collections of great value. The destruction involved the large Delessert herbarium, Professor R. Chodat's personal herbarium and about 200 drawings, representing the labor of ten years, Huber's Mediterranean plants, and various collections loaned by other herbaria for study. Such losses are irreparable.

AT THE MEETING of the Academy of Science of St. Louis on January [illegible] 1899, Mr. Hermann von Schrenk presented informally the results of a study of a sclerotium disease of beech roots which he had observed in southeastern New York during the past summer. The sclerotia, which were formed by the webbing together of rootlets by sterile mycelial threads, have apparently no connection with the mycorhiza of the beech. Mr. von Schrenk's remarks were illustrated by drawings and specimens.—WILLIAM TRELEASE.

THE UNIVERSITY OF TEXAS has established a distinct department of botany, which will begin its separate existence with the next college year. The matter is of special interest since, so far as is known at this writing, this is the first independent department of botany in connection with any southern university. Dr. Wm. L. Bray, who recently received his doctor's degree from the University of Chicago, has been in charge of the botanical work at the University for two years, and will be in charge of the new department.

ON FEBRUARY ninth, a fire in Maxcy House, a dormitory of Brown University, caused considerable damage to the botanical department which occupied quarters in the basement. Fortunately the loss was not so serious as was reported in the daily papers. The herbarium and outfit of apparatus are practically uninjured. Many books and charts are damaged by water, and the economic collections, stored above, were entirely destroyed. We hope that the final result will be to the betterment of the department and that the interruption of its work will be brief.

AT THE MEETING of the Academy of Science of St. Louis, on January 23, 1899, a paper by Professor A. S. Hitchcock, entitled "Studies of subterranean organs, Part I, Compositæ of the vicinity of Manhattan, Kansas," dealing with the structure of a number of rootstocks with reference to their environment, was presented in abstract. Mr. C. H. Thompson also spoke of some plants whose flowers originate endogenously. He mentioned several species of Rhipsalis in which the much reduced leaves grow on tra gular or cylindrical very succulent stems, their axillary buds originating deep down in the soft tissue and sometimes having a passage-way extending toward the surface. In two species of Rhipsalis (*R. paradoxa* and *R. floccosa*) there is no such passage-way, and the bud, in developing, breaks through the epidermis. In *Rhipsalis glaucosa*, a number of accessory abortive flowers were found. *Cuscuta glomerata* was mentioned as the only other plant in which, so far as the speaker knew, subepidermal flowers occur.—WILLIAM TRELEASE.

THE BIOLOGICAL LABORATORY of the Brooklyn Institute of Arts and Sciences, located at Cold Spring Harbor, Long Island, will begin its tenth season on Wednesday, July 5, under the direction of Dr. C. B. Davenport, of Harvard University, and regular class work will continue for six weeks. The laboratory will be open for work from July 3 until August 31. Special students may make arrangements for using the laboratory from the middle of June until the middle of September, or later, if desirous of doing so. The general botanical work will be in the charge of Dr. D. S. Johnson, of Johns Hopkins University, and the bacteriology in charge of Mr. N. S. Davis, of Bucknell University.

THE UNIVERSITY OF MINNESOTA is about to organize a new herbarium classified upon ecological lines. This will be supplementary to the large taxonomic collections already displayed. The ordinary sheets and folio covers will be retained, but plants will be segregated upon their ecological characters. Thus, under the general divisions as blocked out in Schimper's great work, *Pflanzengeographie*, a minute subclassification has been devised—for example, under xerophytes, succulents; under succulents, leaf-succulents; under leaf-succulents, various edaphic groups—rock-succulents, salt-succulents, desert-succulents, etc.—and under these the geographical groups, American, European, Asiatic, etc., according to the geographical classification of Schimper, Drude, and Grisebach, as may be found convenient. A similar classification applies to the other ecological groups. It is believed that this organization of a second herbarium containing duplicates of the taxonomic collection and thoroughly adaptational in its classification will prove of great advantage as an aid to instruction.

THE ANNUAL REPORT of the director of the Field Columbian Museum for 1897-8 shows that the department of botany has been enriched by a large amount of material. "The most important collection acquired during the year was the complete herbarium of the late Mr. M. S. Bebb, including his library, letters, and drawings. Through this collection and that of Schott, obtained the previous year, the herbarium of the museum has [illegible] many important collections projected backward to the middle of the present century. Locally, the herbarium of Mr. Bebb is of great value, as it represents much of the flora of the western states and about all that of Illinois. The collection of willows is very complete, and, in connection with his notes, drawings, and communicated types, is acknowledged to be the very best. Another collection of Yucatan plants has been received from Dr. Gaumer, consisting of many thousand representatives from old and new localities on the peninsula, which collections will form the basis of a fourth contribution to the flora of that region, and will provide a large amount of valuable duplicate material for exchange. In addition to the above more notable accessions, the following sets have been acquired during the year: Pringle and Palmer's new Mexican material; Anthony's Insular Mexican collection; Lumholtz's Mexican plants; Peary Relief Expedition plants of Labrador and Greenland; Schlechter's African centuries; Heller's Sandwich islands, New Mexican, and Texan plants; Millspaugh's West Virginian and New York plants; Pollock's West Virginian species; Lorenz and Hieronymus' Argentine flora; Allen's plants of the Cascade mountains; Dr. Edward Palmer's Florida collection of 1874; Franchsschi's Grecian plants; Lansing's centuries of the plants of the Lake Michigan basin; and the Curator's plants of Mackinac island."

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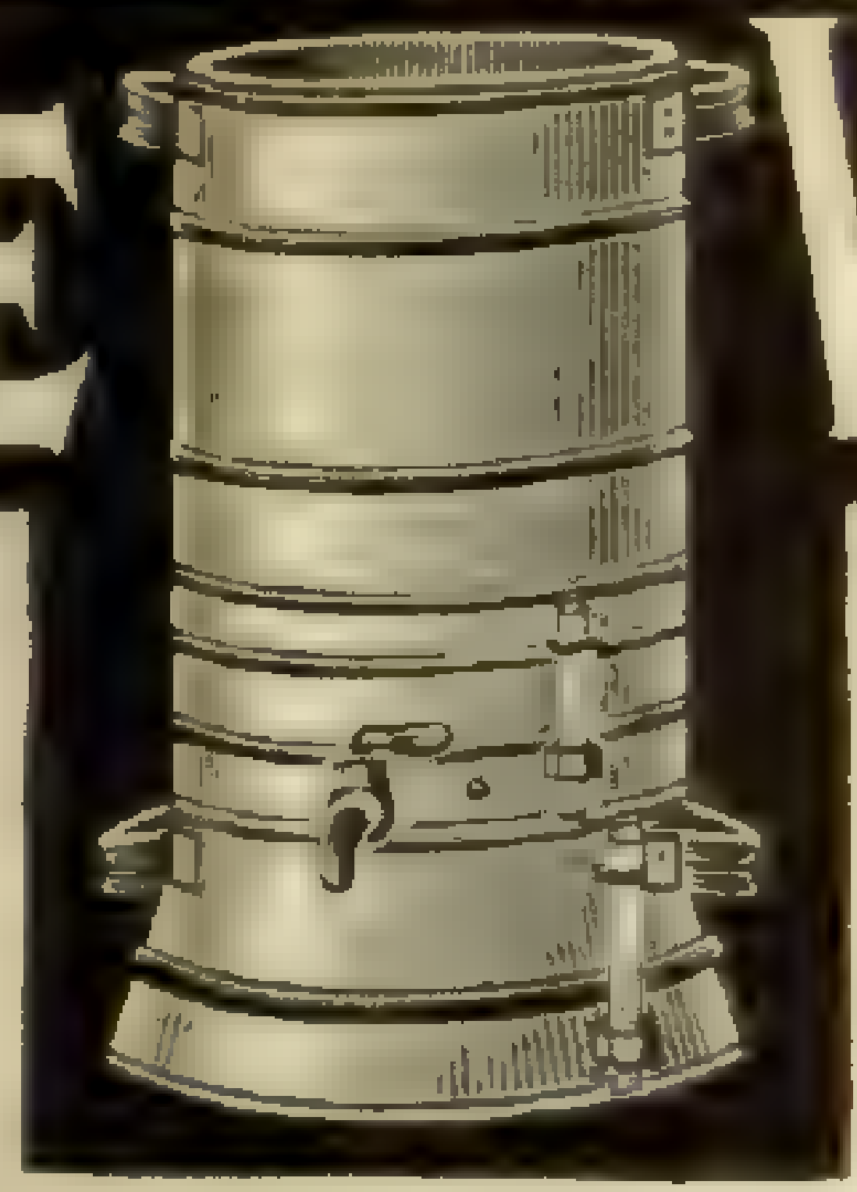

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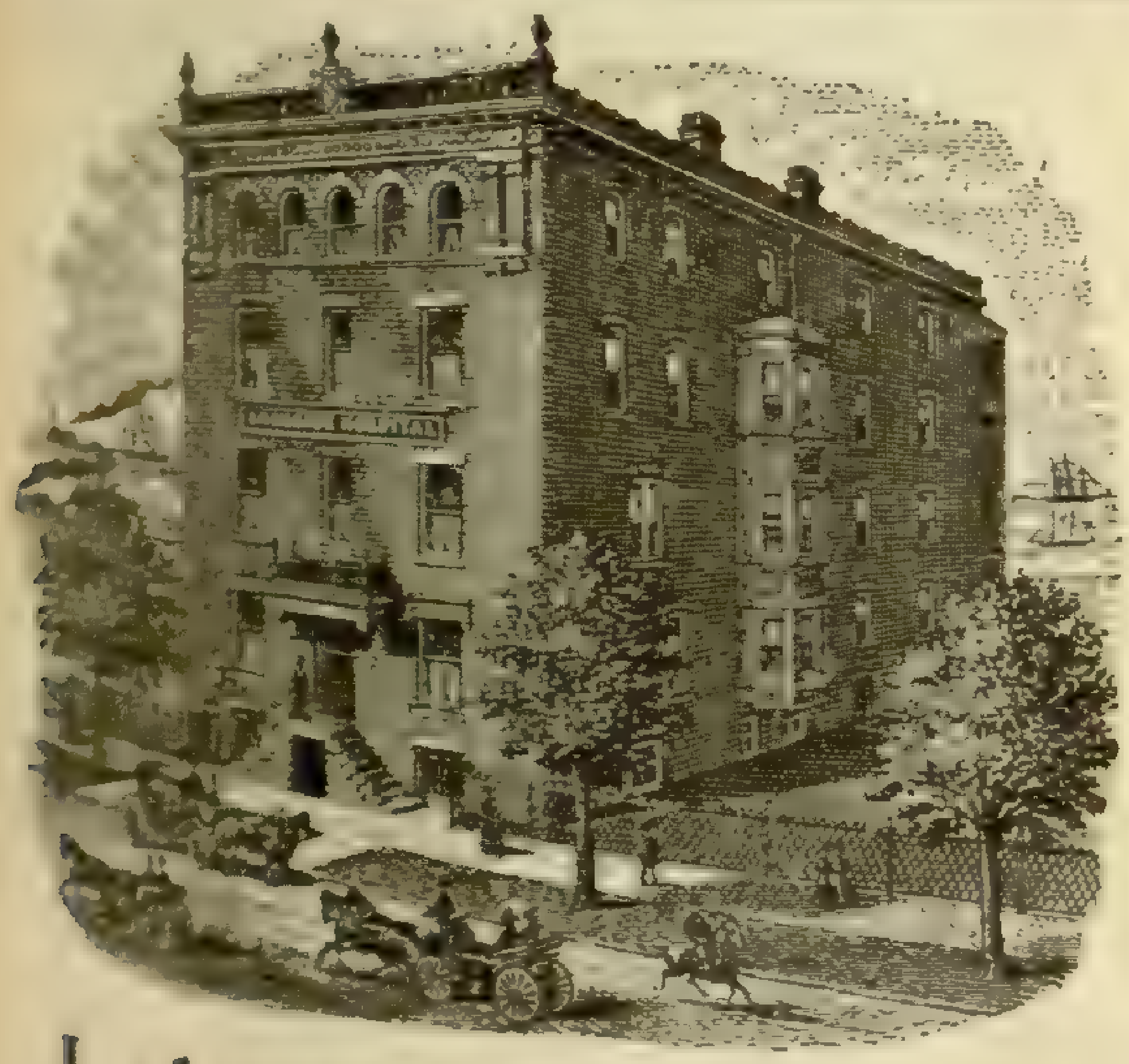

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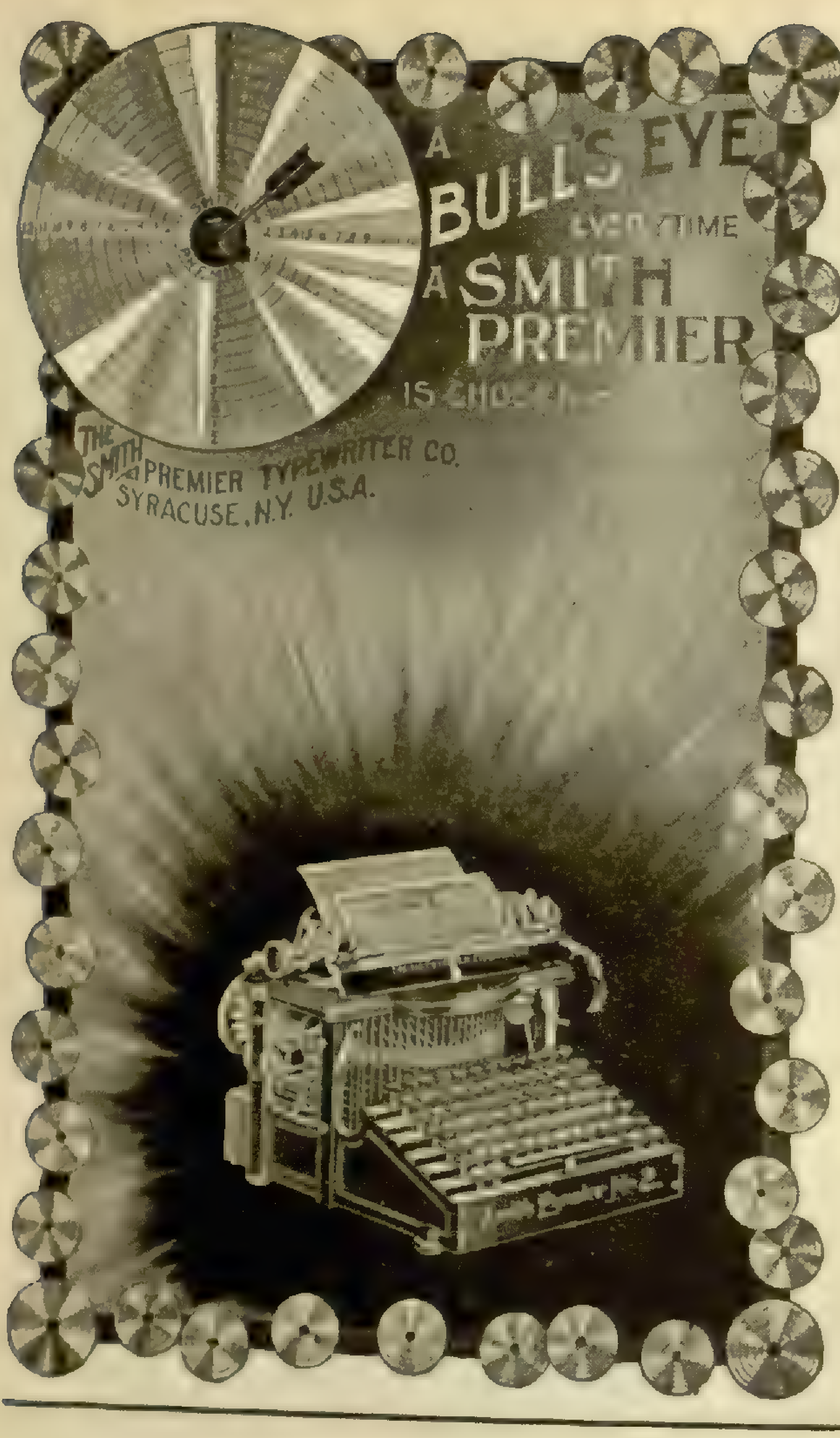
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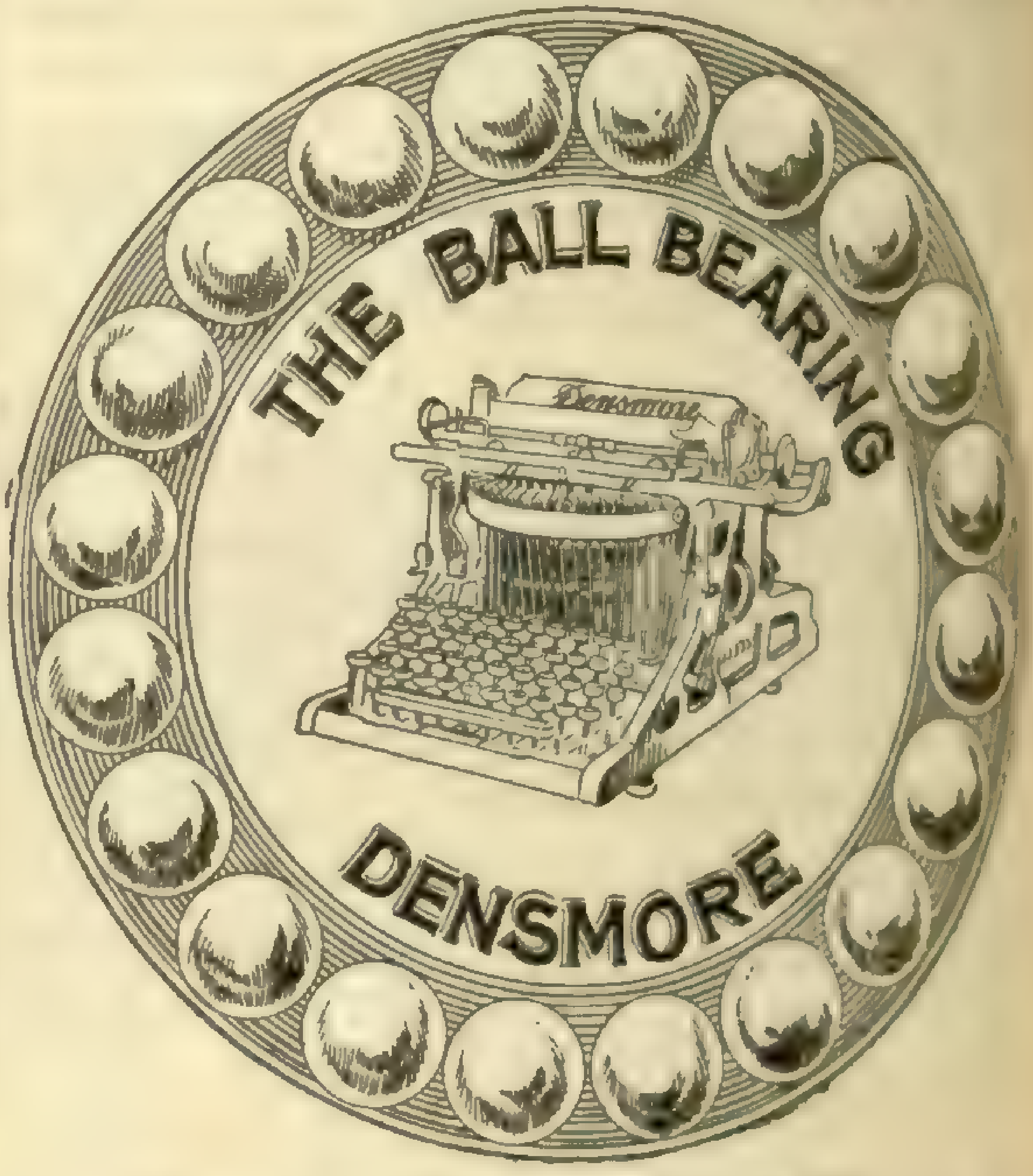
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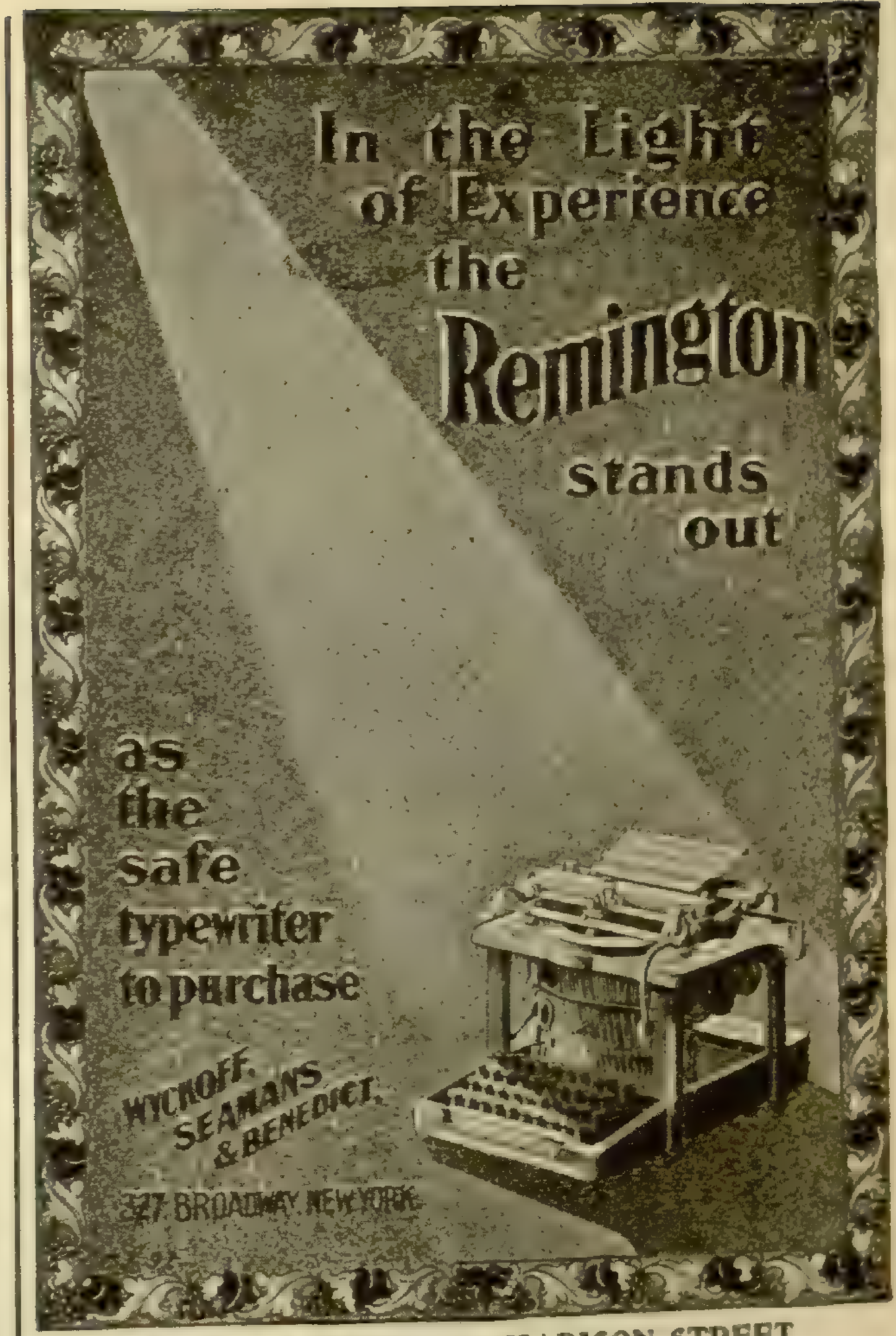
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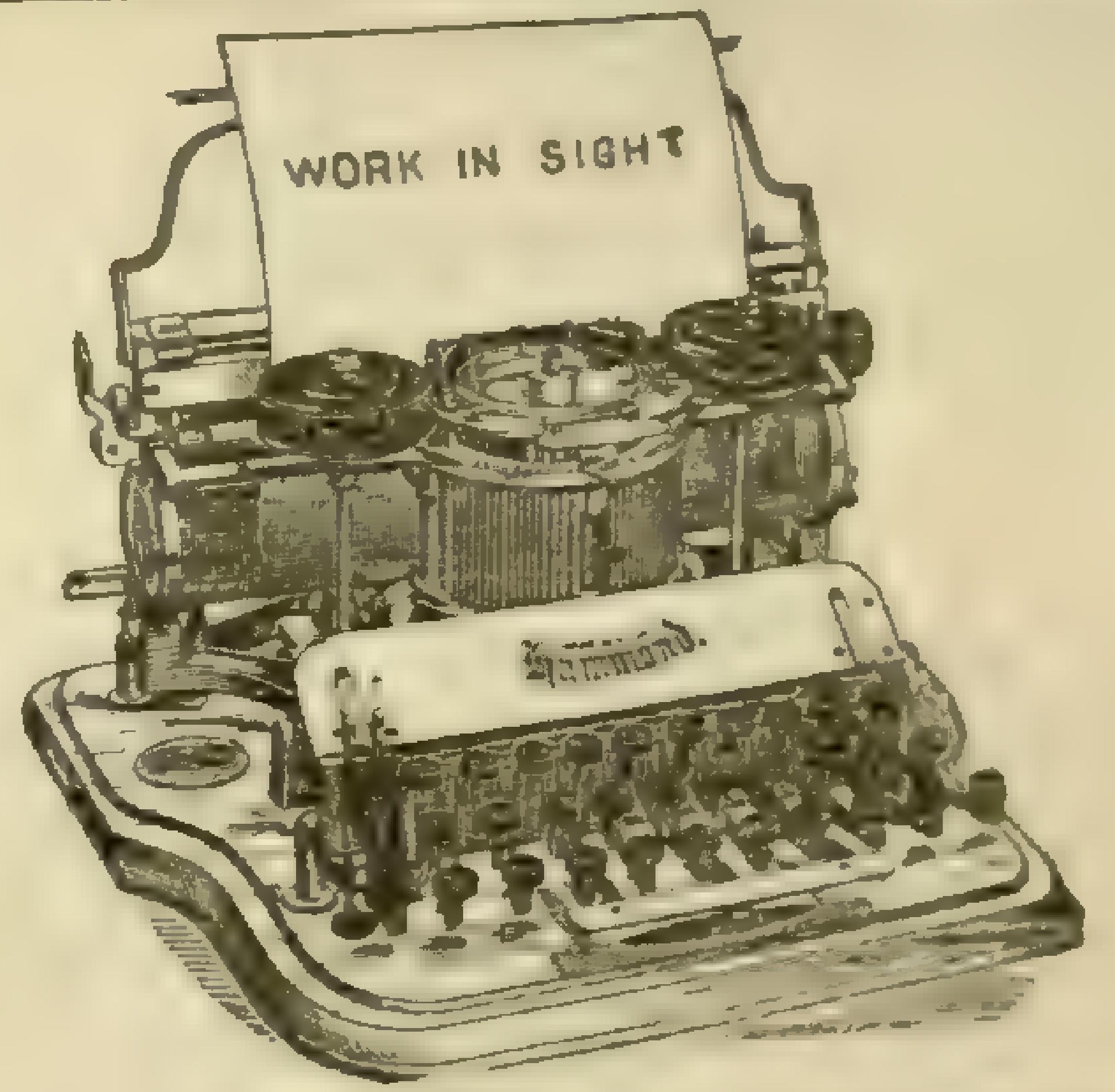
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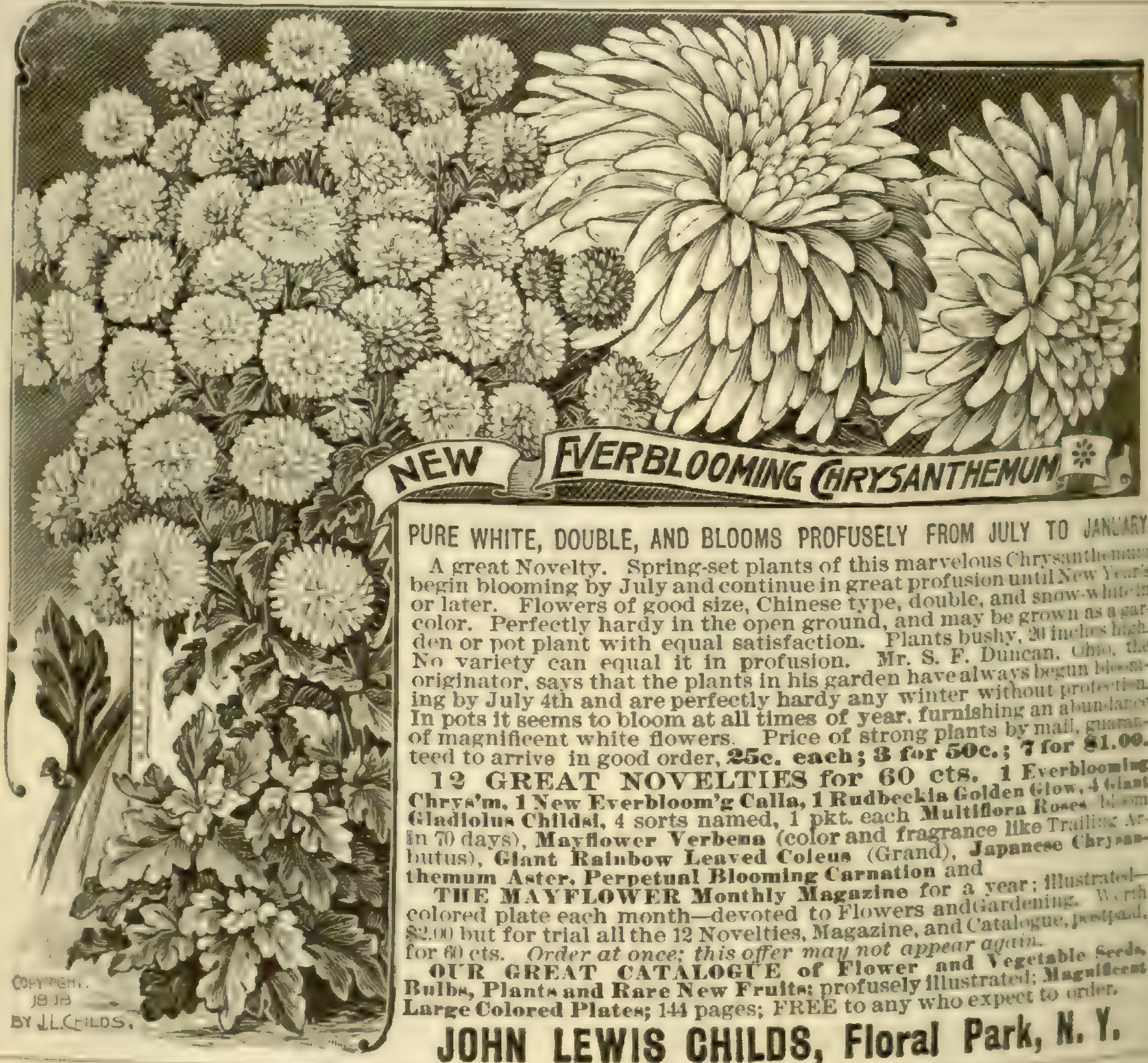

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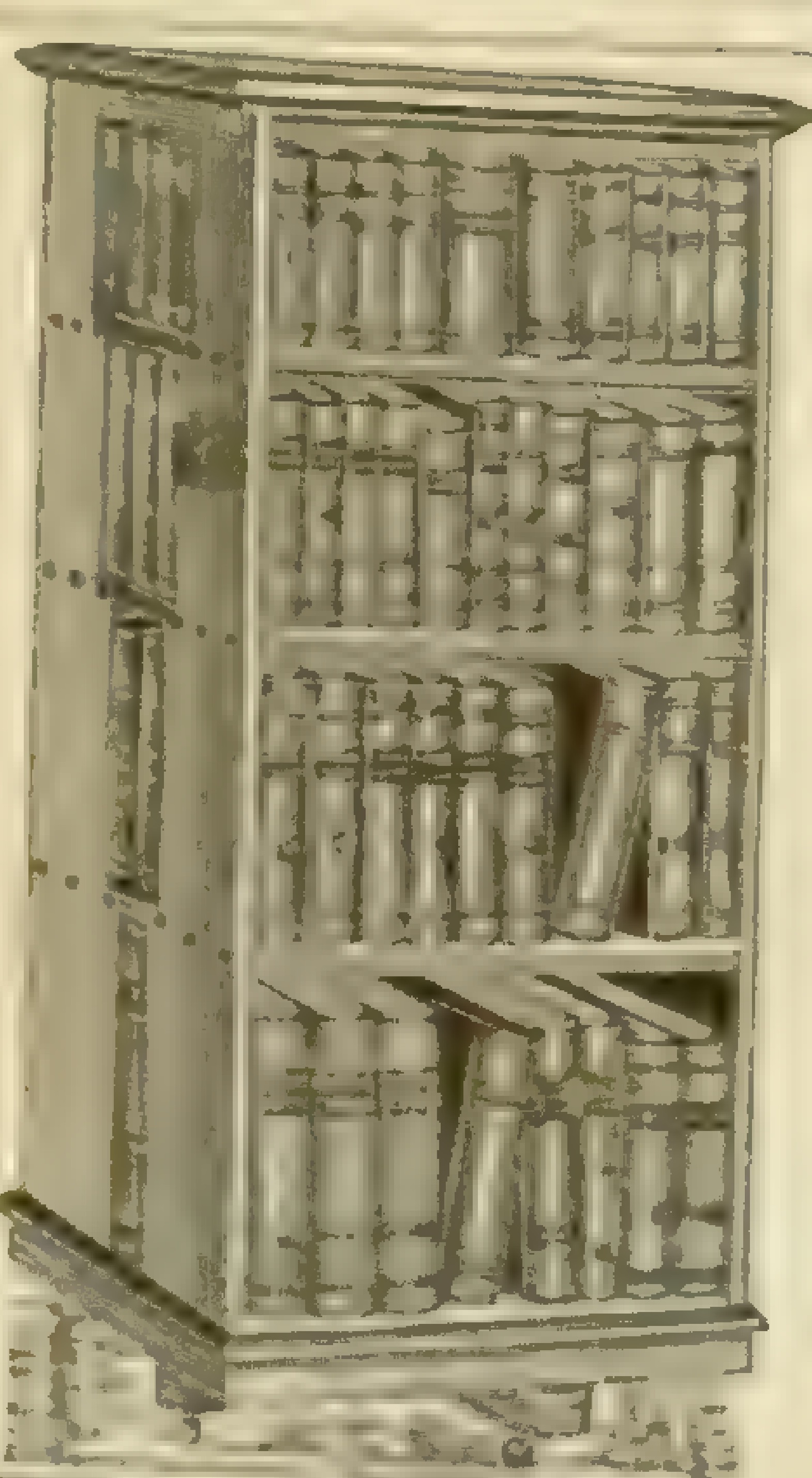

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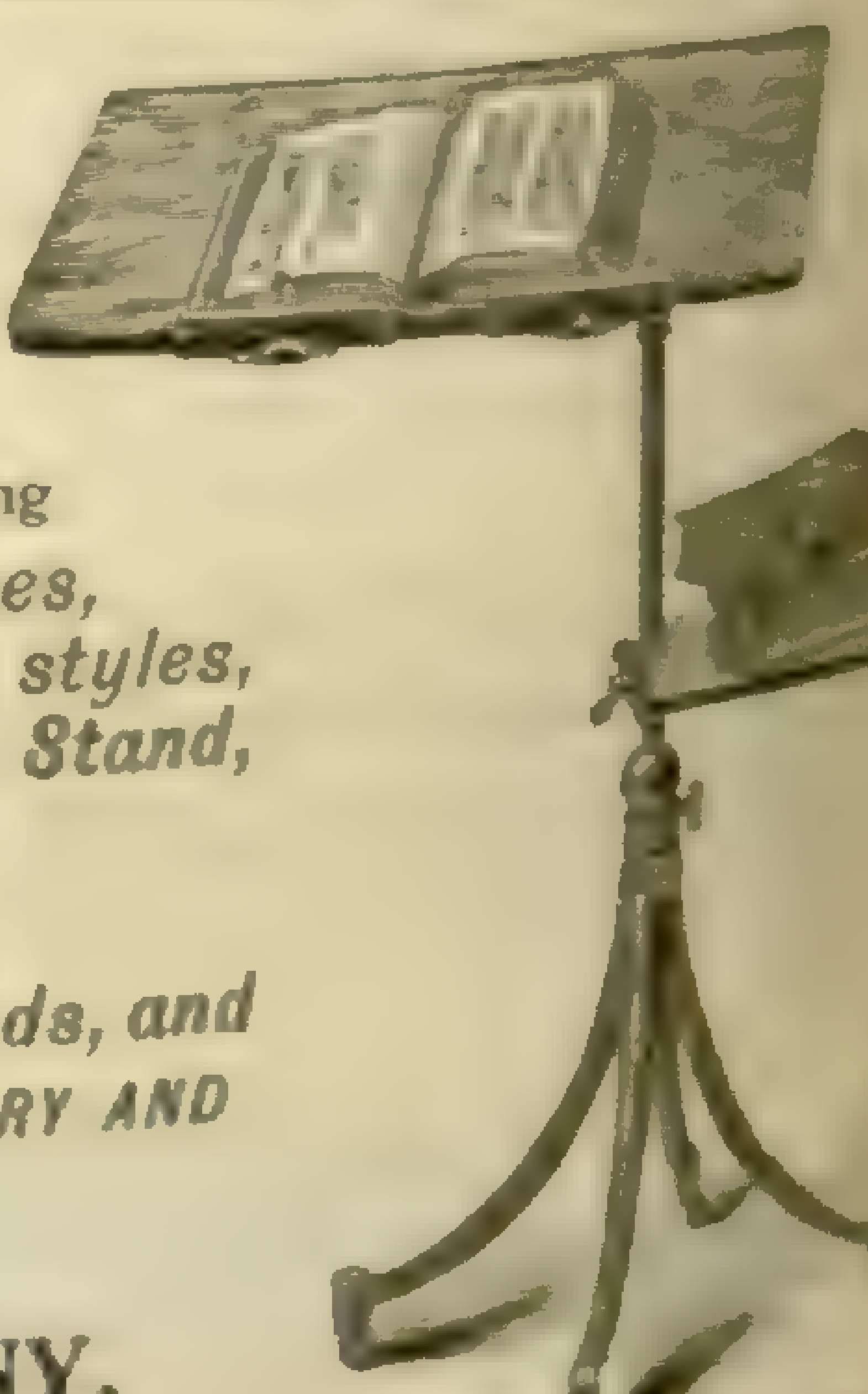

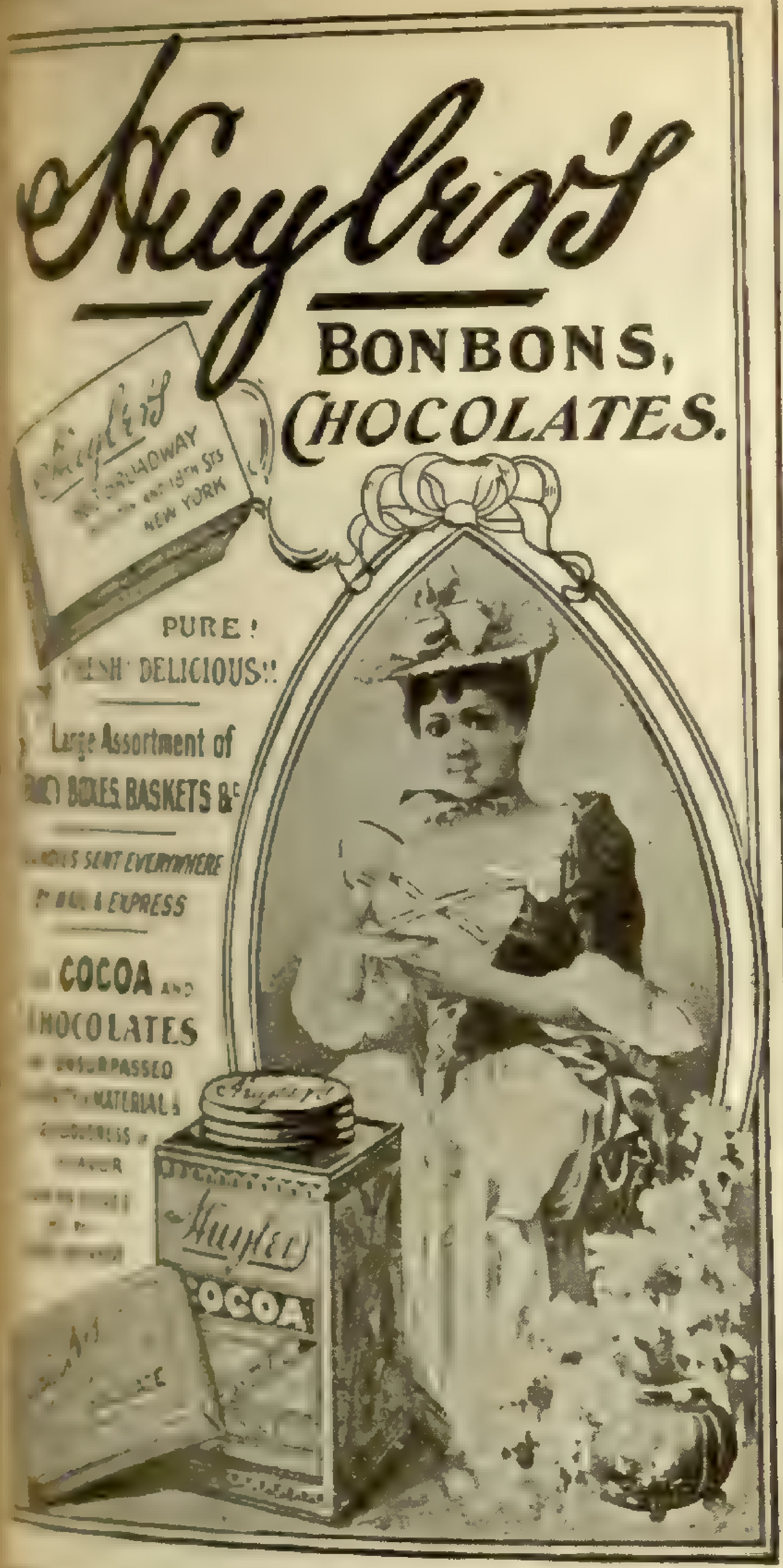

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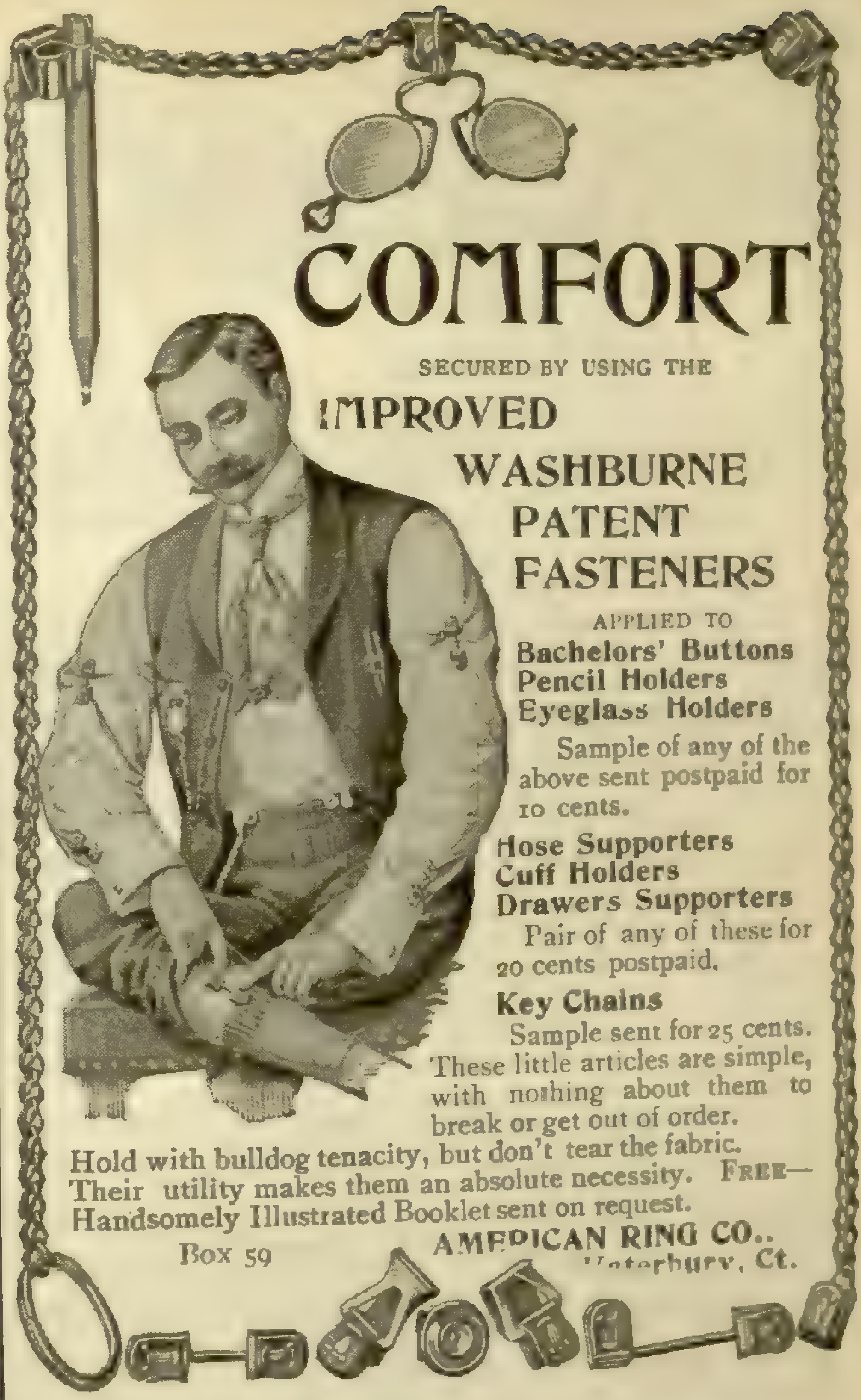

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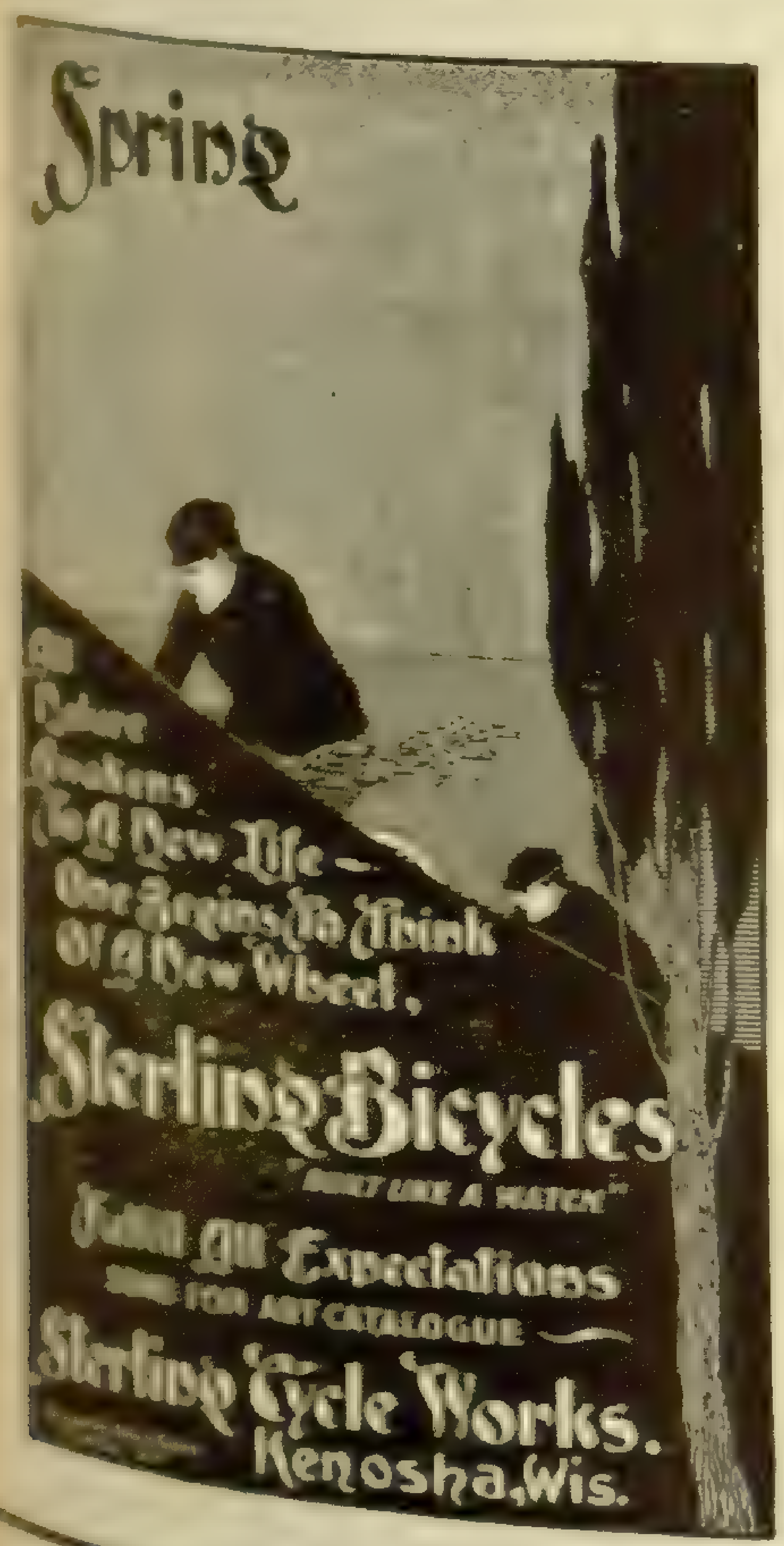

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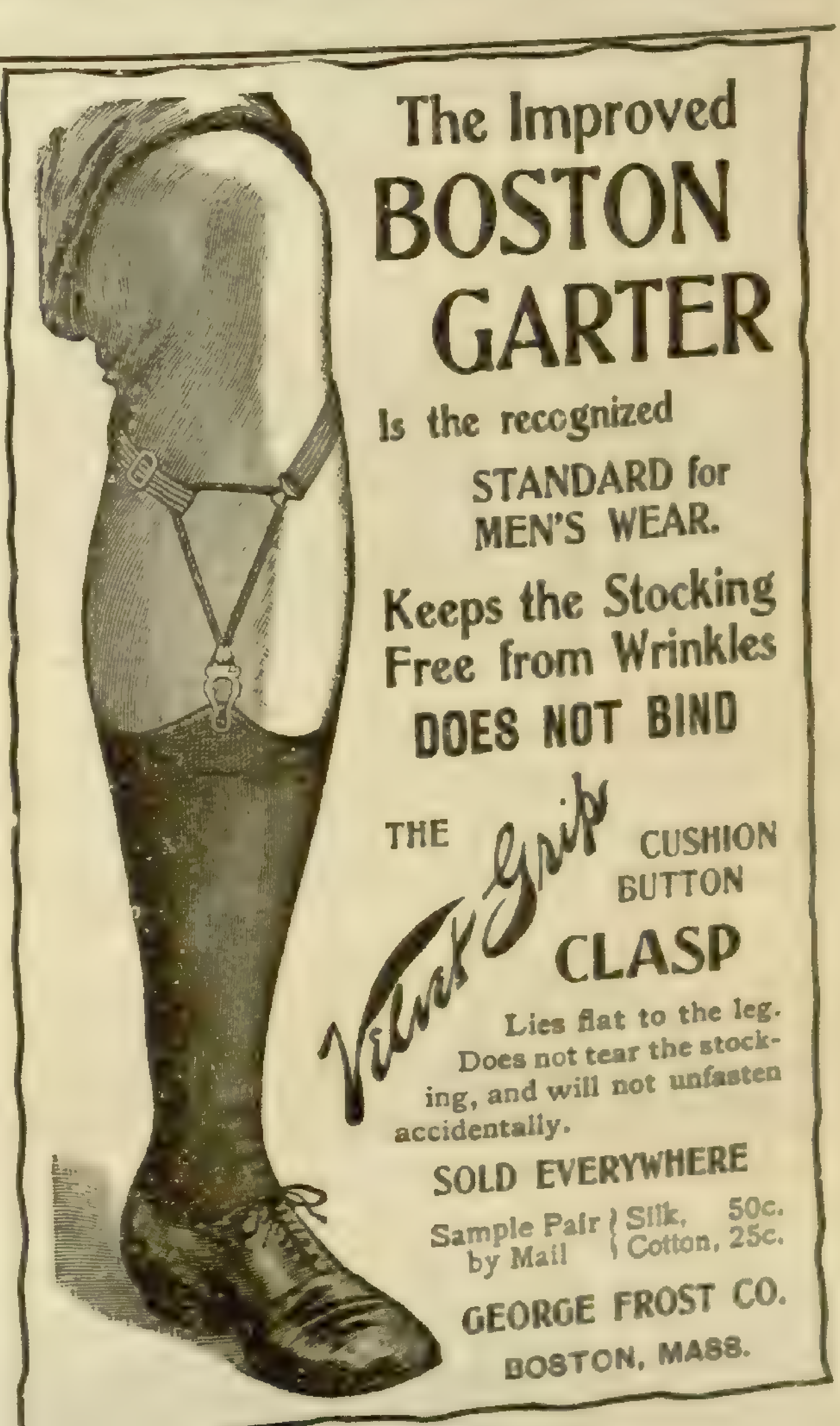

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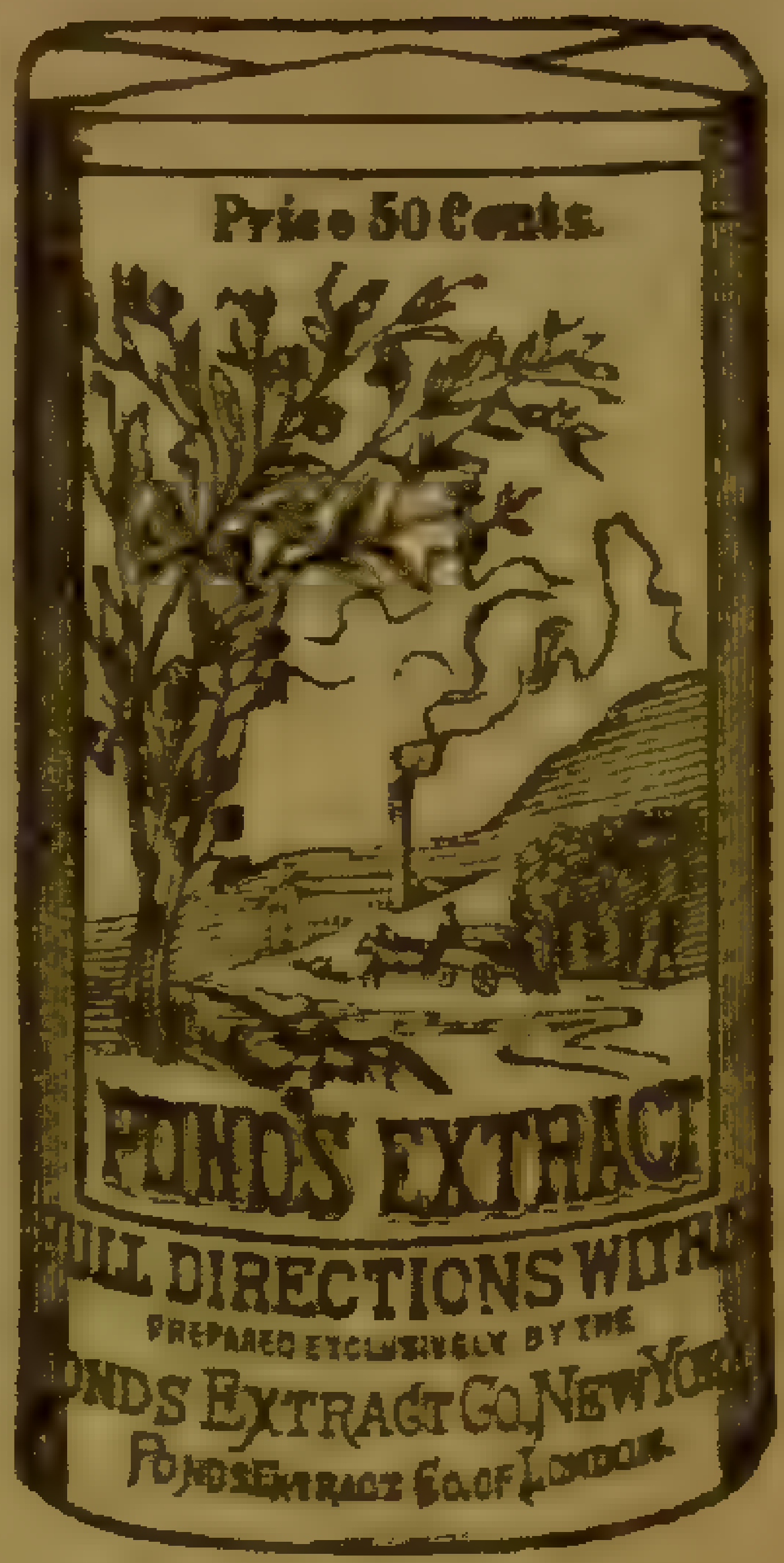
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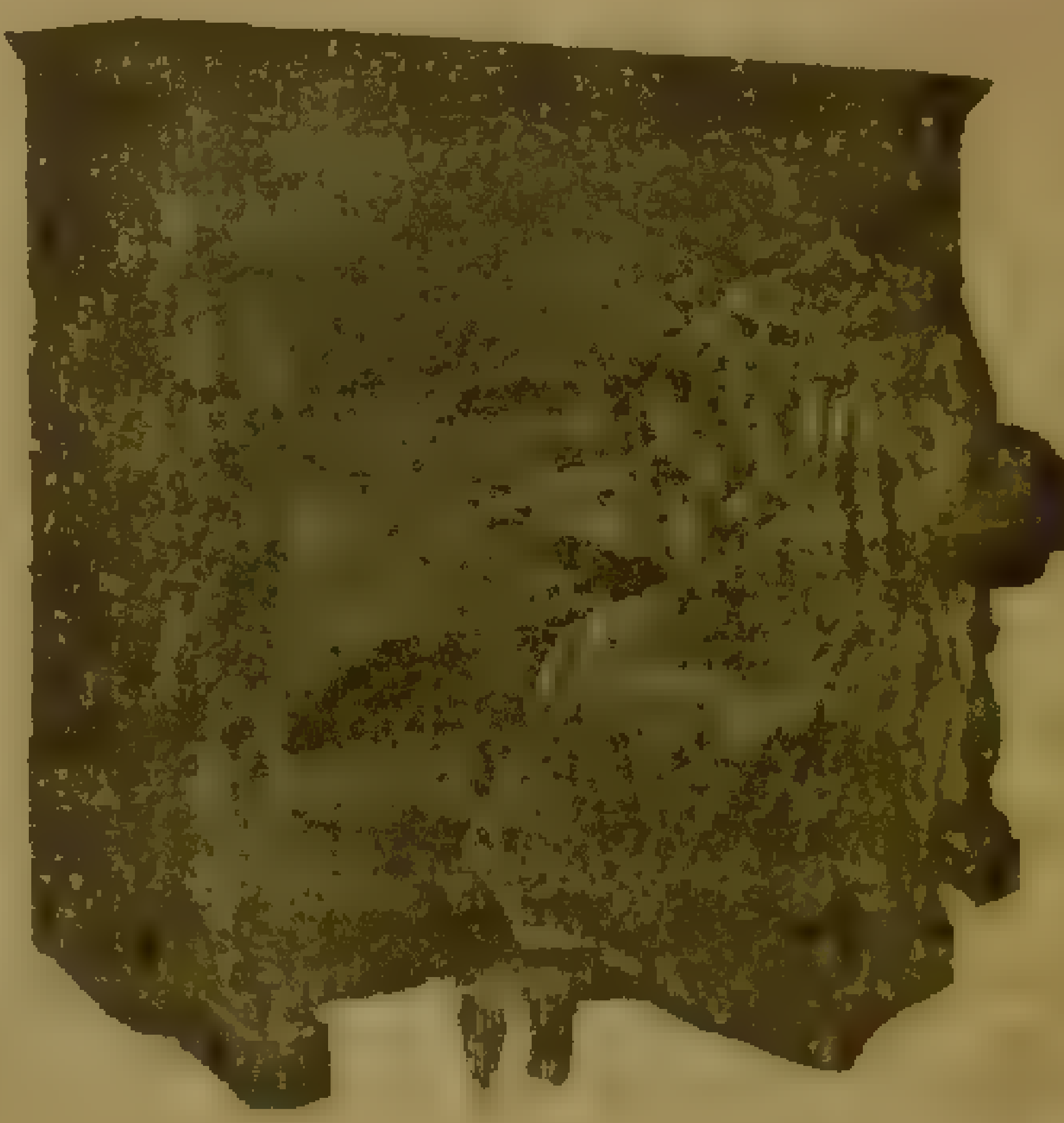

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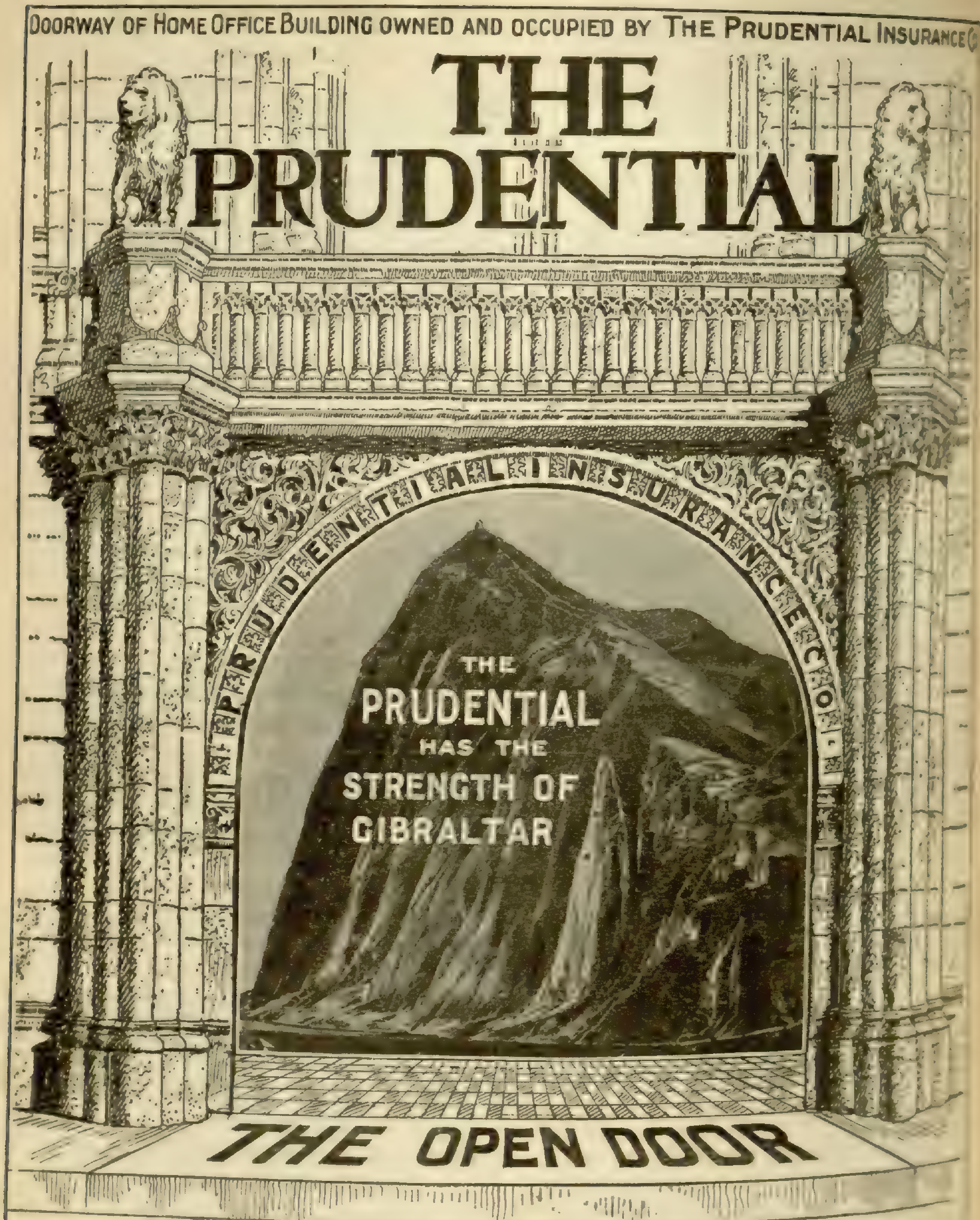
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VOLUME XXVII NUMBER 4

BOTANICAL GAZETTE

APRIL 1899

A CONSPECTUS OF THE GENUS LILIUM.

F. A. WAUGH.

(WITH FIGURES 1–14)

THE lilies have been subjects of great interest to horticulturists and botanists ever since plants have been cultivated and named. The various species come from nearly all parts of the northern hemisphere, and nearly all are markedly variable. It is to be expected that species so much collected, cultivated, selected, described, and named should present great difficulties of discrimination and a most engaging confusion of synonymy.

The genus has been monographed but once since the beginning of the binomial nomenclature. This was by Baker.[1] The American species were once monographed by Watson.[2] The former monograph was published a quarter of a century ago, and the latter twenty years ago. Since that time the number of species has been almost doubled by discoveries in California and the west, in Japan, and especially in China. Many species, formerly little known, have become widely distributed and quite familiar in cultivation. The time seems ripe to resummarize our knowledge of this great and interesting genus. While the writer is painfully conscious of many defects in the subjoined conspectus of species and their synonymy, he is nevertheless hopeful that those interested in the study of the genus will find it convenient at least to have the species and their names brought together.

---

[1] Linn. Soc. Jour. **14**:225–251. 1874.

[2] Am. Acad. Proc. **14**:255–258. 1879.

Acknowledgments are due in particular to Mr. F. H. Horsford, whose excellent collection of lilies at Charlotte, Vermont has been freely placed at my disposal. The accompanying illustrations are from drawings by Mr. C. W. Furlong made under my direction for Professor L. H. Bailey's *Encyclopedia of American Horticulture*. They are available for use here through the kindness of Professor Bailey and the Macmillan Company.

LILIUM *Linn.* Sp. Pl. 302. 1753.

Perianth of six distinct segments, deciduous, clawed, the claws usually distinctly grooved: stamens six, equal, slightly adhering to the ovary below; anthers attached near the middle, dehiscent along the edges: ovary sessile or nearly so, three-celled with many horizontal ovules; style clavate, more or less curved.

Succulent herbaceous plants, with scaly bulbs and leafy upright stems; leaves scattered or whorled: flowers showy, solitary, umbellate, or racemose.—Distributed through the north temperate zone.

KEY TO SPECIES.

Subgenus I. EULIRION Baker, Linn. Soc. Jour. **14**: 225. 1874. Perianth funnel-shaped, with oblanceolate segments which are recurved only at the tip: leaves linear or lanceolate, sessile or nearly so.

a. Tube scarcely widened from base to middle.
  b. Leaves linear, 1-nerved.
    c. Plant low - - - - - - - *L. Philippense* (1).
    cc. Plant tall.
      d. Flowers white, anthers yellow - - *L. Wallichianum* (2).
      dd. Flowers purplish or yellowish, anthers brown - - - - *L. sulphureum* (3).

bb. Leaves lanceolate, 3-nerved or more.
c. Stem creeping, subterranean, bulbiferous *L. Neilgherrense* (4).
cc. Stem usually erect from the bulb - *L. longiflorum* (5).
aa. Tube gradually widening from base to neck.
b. Leaves narrow lanceolate, 1-nerved, not whorled.
c. Plant dwarf.
d. Flowers white - - - - - *L. Yunnanense* (6).
dd. Flowers wine red - - - *L. Delavayi* (7).
cc. Plant medium to tall - - - - *L. Japonicum* (8).
bb. Leaves broad lanceolate, 3–7-nerved, not whorled.
c. Flowers in a spike - - - - *L. candidum* (9).
cc. Flowers few or solitary.
d. Flowers yellow or white.
e. Pedicels bracteate.
f. Flowers white or nearly so - *L. Lowi* (10).
ff. Flowers yellowish - - - *L. primulinum* (11).
ee. Pedicels not bracteate - - - *L. Nepalense* (12).
dd. Flowers pink - - - - *L. rubellum* (13).
bbb. Leaves in whorls.
c. Flowers clear yellow - - - - *L. Parryi* (14).
cc. Flowers whitish or pinkish, spotted *L. Washingtonianum* (15).

Subgenus II. ISOLIRION Baker, Linn. Soc. Jour. **14**: 226. 1874. Flowers usually single or umbellate: perianth erect, spreading, segments recurved only in the extended flower, but not revolute; stamens diverging from the straight style.

a. Leaves more or less whorled.
b. American species, perianth segments spatulate *L. Philadelphicum* (16).
bb. Asiatic species, perianth segments lanceolate *L. medeoloides* (17).
aa. Leaves not whorled.
b. Style shorter than ovary - - - - *L. concolor* (18).
bb. Style longer than ovary.
c. Perianth segments papillose inside.
d. Leaves linear - - - - - *L. Davidi* (19).
dd. Leaves lanceolate.
e. Flowers white - - - - - *L. formosum* (20).
ee. Flowers reddish or yellowish.
f. Stem frequently bulbiferous - - *L. bulbiferum* (21).
ff. Stem not bulbiferous - - *L. croceum* (22).

cc. Perianth segments naked inside.
d. Leaves broad lanceolate, crowded - *L. elegans* (23).
dd. Leaves linear, much crowded - - *L. myriophyllum* (24).
ddd. Leaves linear, scattered.
e. American species, flowers reddish - *L. Catesbæi* (25).
ee. Asiatic species, flowers white - *L. Bakerianum* (26).

Subgenus III. ARCHILIRION Baker, Linn. Soc. Jour. **14**: 226. 1874. Perianth broadly funnelform at the base; segments finally broadly spreading, or twisted revolute from below the middle, usually prominently papillose within; stamens diverging from curved style.

a. Leaves sessile.
b. Flowers large, reddish, segments revolute - *L. tigrinum* (27).
bb. Flowers small, purplish, rotate - - - - *L. oxypetalum* (28).
aa. Leaves short petiolate.
b. Flowers dull reddish.
c. Flowers few, small - - - - - - *L. papilliferum* (29).
cc. Flowers many, large - - - - *L. Henryi* (30).
bb. Flowers white, yellowish, or light pink.
c. Flowers open funnelform, on rather short straight pedicels - - - - - - *L. auratum* (31).
cc. Flowers on long cernuous pedicels, segments twisted revolute - - - - - - *L. speciosum* (32).

Subgenus IV. MARTAGON Rupp. Fl. Jen. ed. Hall. 148. 1745; Baker, Linn. Soc. Jour. **14**: 226. 1874. Flowers strongly nodding, with perianth segments very revolute: stamens diverging on all sides from the curved style.

a. Leaves whorled.
b. Leaves nearly all in large whorls of 8 or more.
c. Bulb large, horizontally elongated - - - *L. puberulum* (33).
cc. Bulb small, globose.
d. European species, flowers purplish or whitish - - - - - - - *L. Martagon* (34).
dd. Japanese species, flowers yellow, spotted - *L. maculatum* (35).
ddd. American species, flowers mostly reddish.
e. Atlantic coast species, flowers reddish-yellow, black spotted - - - - - *L. superbum* (36).
ee. Pacific coast species.
f. Perianth forming a tube - - - *L. occidentale* (37).
ff. Perianth scarcely tubular - - - *L. pardalinum* (38).

bb. Leaves in small whorls of less than 8, or partly scattered.

c. American species, flowers yellow - - - *L. parviflorum* (39).

cc. Asiatic species, flowers reddish or whitish.

d. Leaves 1-nerved - - - - - *L. Taliense* (40).

dd. Leaves 3–5-nerved.

e. Stem puberulent, leafy throughout - - *L. Honkongense* (41).

ee. Stem glabrous, with few leaves - - *L. avenaceum* (42).

aa. Leaves not whorled.

b. Leaves lanceolate, many-nerved.

c. Perianth revolute above the middle.

d. Bulb large, ovoid; flowers yellow - - *L. monadelphum* (43).

dd. Bulb small, elongated; flowers whitish *L. polyphyllum* (44).

cc. Perianth revolute to below the middle, flowers reddish - - - - - - - *L. carniolicum* (45).

bb. Leaves linear, one or few-nerved.

c. Perianth segments $1.2–2.5^{cm}$ broad.

d. Bulb small, plant with subterranean bulbiferous stem - - - - - - *L. Maximowiczii* (46)

dd. Bulb medium or large, globose; stem erect - - - - - - - *L. testaceum* (47).

cc. Perianth segments $0.6–1.2^{cm}$ broad.

d. Leaves crowded.

e. Perianth segments smooth inside - - *L. ochraceum* (48).

ee. Perianth segments papillose within.

f. Flowers yellow - - - - - *L. Fargesii* (49).

ff. Flowers reddish inside.

g. Flowers whitish without, leaves very narrow - - - - - - *L. pomponium* (50).

gg. Flowers red outside, stem very leafy *L. Chalcedonicum* (51).

dd. Leaves scattered.

e. Style shorter than ovary - - - *L. callosum* (52).

ee. Style longer than the ovary.

f. Perianth segments usually spotted and papillose inside - - - - - *L. Sutchuense* (53).

ff. Perianth segments smooth and unspotted inside - - - - - - *L. tenuifolium* (54).

Subgenus V. PSEUDOMARTAGON, subgen. nov.

Inflorescence usually paniculate, with flowers tending to be erect, horizontal, or only slightly nodding at length; perianth funnelform, with segments slightly recurved at the tip, or finally recurved from the middle.

a. Perianth narrow, segments only slightly spreading at the tip.
  b. Leaves more or less whorled.
    c. Flowers only one or two - - - - - - *L. Bolanderi* (55).
    cc. Flowers usually many.
      d. Atlantic coast species - - - - - *L. Grayi* (56).
      dd. Pacific coast species; bulb globose - - *L. parvum* (57)
      ddd. Pacific coast species; bulb elongated - *L. nitidum* (58).
  bb. Leaves not whorled - - - - - - - *L. maritimum* (59).
aa. Perianth spreading, segments rotate spreading or somewhat recurved.
  b. Atlantic coast species; flowers yellow marked with red - - - - - - - - *L. Canadense* (60)
  bb. Pacific coast species; flowers orange marked with red - - - - - - - - *L. Purdyi* (61).

Subgenus VI. CARDIOCRINUM Lindl. Veg. Kingd. 205. 1847. Perianth funnel-shaped, with oblanceolate segments, recurved only at the apex: leaves stalked, cordate-ovate.

a. Inflorescence centripetal.
  b. Lower leaves tinged with red - - - - - *L. cordifolium* (62).
  bb. Lower leaves clear green - - - - - - *L. giganteum* (63).
aa. Inflorescence centrifugal - - - - - - *L. mirabile* (64).

1. L. PHILIPPENSE Baker, Gard. Chron. **1873**: 1141.

Bulb perennial, ovoid: stem 4.5–6^{dm} high, slender, erect: leaves 30–40, scattered, narrow linear, 7.5–10^{cm} long, 3-nerved: flowers solitary, horizontal, white, slightly tinged with green toward the base outside, 15–20^{cm} long, trumpet shaped; perianth segments oblanceolate, reflexed only at the tip, contracted into a long claw: stamens a little shorter than the perianth; pollen yellow.

Philippine islands.

2. L. WALLICHIANUM Schultes f. Syst. Veg. **8**: 1689. 1830.

L. Japonicum D. Don. (non Thunb.) Prod. Fl. Nep. 52. 1802.
L. longiflorum Wallich (non Thunb.) Tent. Fl. Nep. 40. 1826.
L. Batisua Hamilt. in Baker, Linn. Soc. Jour. **14**: 229. 1874. (*L. Batisua*
Hamilt. in D. Don, Prod. Fl. Nep. 52. 1802, nomen nudum.

Bulb thick, ovoid, 5–7.5$^{\mathrm{cm}}$ long, with thick, acute, much imbricated scales: stem 12–18$^{\mathrm{dm}}$ high, stiff, horizontal at the base: leaves 50–60, scattered or crowded, sessile, ascending, the lower 15–23$^{\mathrm{cm}}$ long, 3-nerved, the upper shorter, wider, and often 5-nerved, and often bearing bulbils in the axils: flowers usually solitary, or sometimes two or three, horizontal or nearly so, white, tinged with green outside, fragrant; perianth segments oblanceolate-unguiculate, 18–23$^{\mathrm{cm}}$ long: stamens shorter than the perianth; anthers yellow: style and ovary together equaling the stamens.

Central Himalayas.

3. L. SULPHUREUM Baker, Bot. Mag. *t. 7257*. 1892.

L. Wallichianum superbum Baker, Gard. Chron. III. **10**:480. 1891.
L. Wallichi superbum hort. in Baker, loc. cit.
L. ochroleucum The Garden (non Wallich) **40**:338. 1891.

Bulb large, globose: stem erect, 18–20$^{\mathrm{dm}}$ high: leaves numerous, scattered, spreading, linear, the lower 7.5–10$^{\mathrm{cm}}$ long, the upper growing gradually shorter, and many of them producing bulbils in their axils: flowers usually two or three, pendant on long peduncles, fragrant, sulphur yellow, tinged outside with claret-red; perianth funnel-shaped, 18–20$^{\mathrm{cm}}$ long, the oblanceolate-oblong segments permanently connivent in the lower two-thirds, recurving in the upper third; outer segments but little over 2.5$^{\mathrm{cm}}$ broad, inner nearly 5$^{\mathrm{cm}}$ broad: stamens 35$^{\mathrm{cm}}$ shorter than the perianth segments; anthers over 25$^{\mathrm{cm}}$ long, with brown-red pollen: style much overtopping the anthers, curved at the apex; stigma large.

Burmah.

4. L. NEILGHERRENSE Wight, Ic. *t. 2031–2*. 1856.

L. tubiflorum Wight, Ic. *t. 2033–4*. 1856.
L. Wallichianum Wight (non Schultes), Ic. *t. 2035*. 1856.
L. Neilgherricum hort. in Lem. Illus. Hort. **10**: *t. 353*. 1863.
L. Metzii Steud. in Duch. Soc. Hort. Par. Jour. II. **4**:556. 1870.

Bulb globose, 5–7.5$^{\mathrm{cm}}$ in diameter, with thick lanceolate scales; stem 3–6$^{\mathrm{dm}}$ high, stiff, creeping at the base: leaves 30–40, crowded, distinctly 3–5-nerved: flowers 1–3, ascending, white, fragrant, 15–18^{cm} long, trumpet-shaped; perianth segments oblanceolate-unguiculate, reflexed only at the tip: stamens a little shorter than the perianth; pollen yellow: ovary and style as long as the stamens; capsule oblong, obtuse angled.

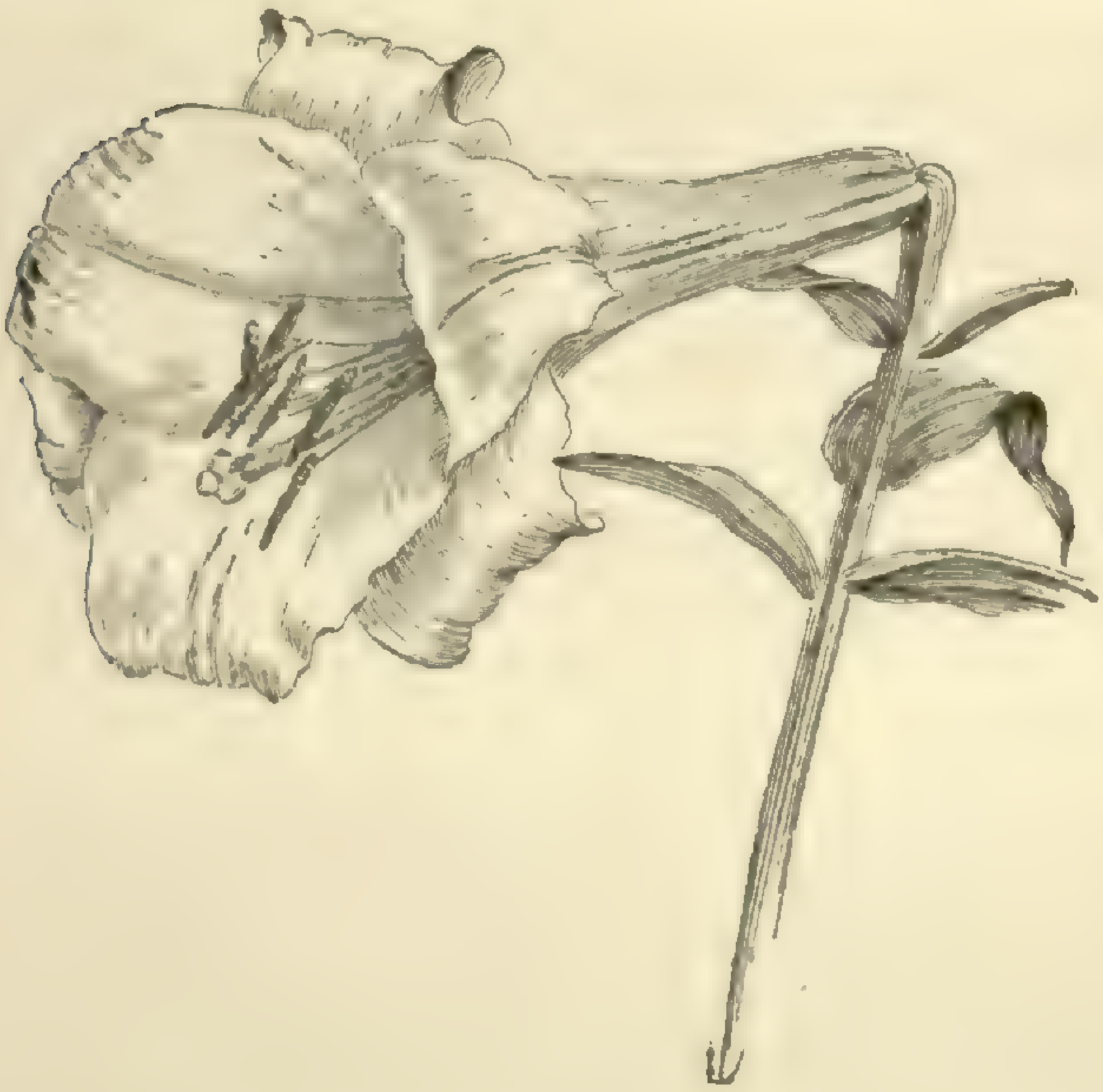

FIG. 1.—Lilium Neilgherrense.

India.

5. L. LONGIFLORUM Thunb. Linn. Soc. Trans. **2**: 333. 1794.

L. candidum Thunb. (non Linn.) Fl. Jap. 133. 1784.
L. speciosissimum hort. Baxt. in Loud. Hort. Brit. Suppl. **2**: 645. 1830.
L. speciosum Sieb. in Verh. Batav. Gen. **12**: 15. 1830.
L. Takesima hort. in Baker, Linn. Soc. Jour. **14**: 230. 1874.
L. abchasicum hort. in Baker, loc. cit.

Bulb perennial, globose, with lanceolate scales: stem [illegible] high, erect: leaves 20–40, scattered, ascending, 5-nerved, 7–10^{cm} long: flowers often solitary, sometimes two or three, nearly horizontal, fragrant, waxy white; perianth narrow funnel-form: segments oblanceolate, obtuse, reflexed in the upper quarter: anthers narrow, yellow, with yellow pollen: capsule narrow oblong, obtuse, angular, umbilicate.

Temperate regions of Japan, China, and Formosa. One of the best known species in cultivation.

Var. EXIMIUM Nicholson, Dict. Gard. **2**: 271. 1887.

L. eximium Comt. in Spae. Mem. Gen. Lis. 1845.
L. Jama-juri Sieb. & DeVriese, Tuinbow Fl. **1**: 319. *t.* [illegible]. 1855.
L. eximium Wilsonii hort. Angl. in Baker, Linn. Soc. Jour. **14**: [illegible] 1874.
L. Harrissi hort. in Carr. Rev. Hort. **55**: 211. 1883.

Bears usually more and larger flowers on more leafy stems.

Extensively forced by florists. Sometimes called Bermuda Easter lily.

6. L. Yunnanense Franchet, Jour. Bot. **6**: 314. 1892.

Bulb ovate, with fleshy ovate lanceolate, sharply imbricate scales: stem slender, 3–6^{dm} high, scabrous with slender hairs, without leaves for a short distance at the base: leaves sparse, long, narrowly lanceolate, 3-nerved, scabrous along the nerves and margins: flowers white, or on the outside slightly tinged with purple, not at all or sparingly punctate, 8–9^{cm} long, solitary, or more rarely 2–3, nodding when young, later erect; perianth broadly open-tubular from the base, with spreading segments; nectar furrow bare: stamens half as long as the perianth; pollen yellow: style thick, a little longer than the ovary.

Yun-nan, China. "The flowers resemble *L. Japonicum* Thunb., but are smaller. Leaves like *L. elegans*."—Franchet.

7. L. Delavayi Franchet, Jour. Bot. **6**: 314. 1892.

Stem slender, 3–6^{dm} high, leafless below, then sparsely leaved: leaves sometimes short lanceolate, 3–4^{cm} long, at other times linear-lanceolate or linear, 3-nerved, densely and roughly papillose along the nerves and margins: flowers solitary or more rarely two or three, at first nodding, but horizontal just before bloom, 8–9^{cm} long, wine-red, marked with crowded reddish dots; perianth for the most part broadly tubular, segments recurved above, lower part gradually narrowed: stamens less than half the length of the perianth, with filaments smooth; pollen yellow: style twice as long as the ovary.

Yun-nan, China.

8. L. Japonicum Thunb. Fl. Jap. 133. 1784.

L. odorum Planch. Fl. d. Serres I. **9**: 53. 1853–4.

Bulb perennial, globose: stem 3–6^{dm} high: leaves 12–20, scattered, ascending, thin, glabrous, lanceolate, 5–7-nerved, 10–15^{cm} long: flowers often solitary, sometimes two or three, white on the inside, tinged more or less with purple on the outside, fragrant; perianth 10–15^{cm} long, wide funnel-shaped, gradually widening; segments oblanceolate-unguiculate, obtuse, recurved in upper third: filaments less than one third the length of the perianth; pollen red: ovary with style slightly longer than the stamens; capsule obovoid, deeply and obtusely 6-angled.

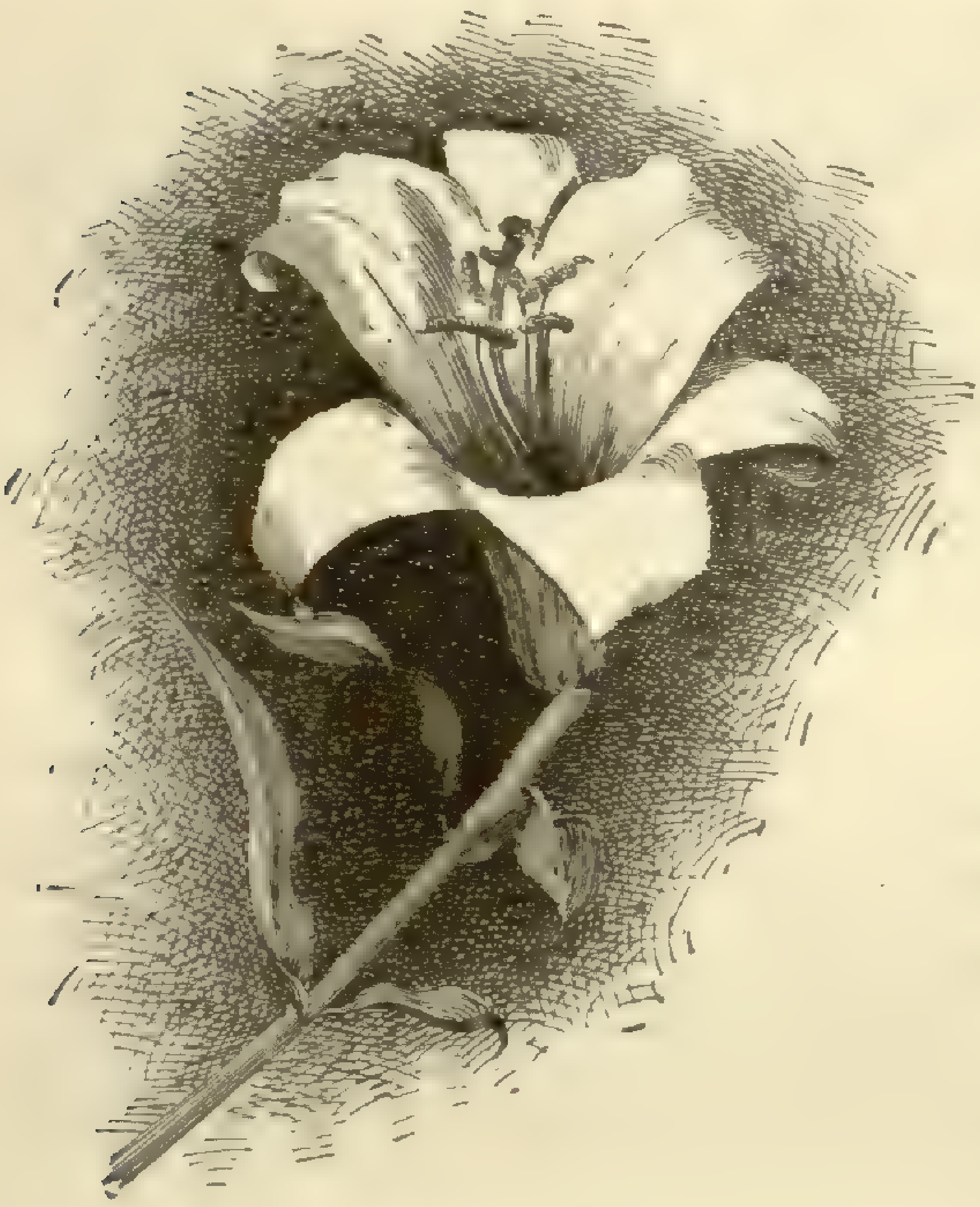

FIG. 2.—Lilium Japonicum.

Japan. Much grown in gardens, especially in its striking varieties, of which the following are the most noteworthy.

Var. BROWNII Nicholson, Dict. Gard. **2**:270. 1887.

L. Brownii Poit. Rev. Hort. II. **2**:406. 1843.

A robust, leafy, large-flowered variety, with perianth white inside and deep vinous purple outside.

Var. ROSEUM hort. in Vilm. Fl. Pl. Terre 581. 1894. [Ed. 4.]

L. Krameri hort. Teutschel in Hook. f. Bot. Mag. *t. 6058.* 1873.
L. Kramerianum Hook. f. loc. cit.
L. Krameri Barrianum Baker, Linn. Soc. Jour. **14**:231. 1874.
L. Belladona hort. Leicht in Baker, op. cit. 232. 1874.
L. Elisabethæ Leicht. in Vilm. Fl. Pl. Terre 581. 1894. [Ed. 4.]

Differs from the species in a more slender, graceful habit, and in the beautiful pale rose colored flowers.

Var. ALEXANDRÆ hort. Wallace in Baker, Gard. Chron. III **14**:86. 1893.

L. Alexandræ hort. in Baker, loc. cit.
L. Ukeyuri hort. in Jour. Hort. 1893.

A pure white variety with longer style and broader leaves. Uke island, Japan.

9. L. CANDIDUM Linn. Sp. Pl. 302. 1853.

L. Byzantinum Steud. Nom. **2**: 44. 1840. [Ed. 2.]
L. peregrinum Mill. Dict. n. 2. [Ed. 8.]
L. candidum striatum Van Houtte, Fl. de Serr. *t. 735*.
L. candidum spicatum hort. in Baker, Linn. Soc. Jour. **14**:232. 1874.
L. candidum peregrinum Linn. in Baker, loc. cit.

Bulb ovoid, perennial large: stem leaves scattered sessile, acute bract-like above: stem 6–12$^{\text{dm}}$ high, erect, stiff: flowers 5–25 in a raceme, 10–15$^{\text{cm}}$ long and wide, pure white, fragrant, segments revolute in upper third, obtuse: stamens short, bearing yellow anthers: style and ovary much longer than the stamens.

Southern Europe. Several garden forms have been described as varieties of this species. Such are var. *striatum* hort., var. *spicatum* hort., and var. *peregrinum* Linn. They do not seem to be worthy of botanical rank however. One of the most ornamental species, and an old favorite, though considerably subject to disease.[3]

10. L. LOWI Baker, Bot. Mag. *t. 7232*. 1892.

L. Nepalense Coll. & Hem. (non D. Don), Linn. Soc. Jour. **28**:138. 1890.

Bulb globose, 5$^{\text{cm}}$ in diameter, scales smal lanceolate: stem glabrous, stiffly erect, 9–12$^{\text{dm}}$ high: leaves very numerous, scattered, sessile, linear, erecto-patent, 5–7.5$^{\text{cm}}$ long: flowers about three, corymbose or umbellate, on long cernuous peduncles with a linear leaf at the middle; perianth open funnel-shaped, 7.5–10$^{\text{cm}}$ long; fully expanded limb 7.5$^{\text{cm}}$ in diameter, segments oblong-lanceolate, the inner and outer nearly uniform, white with a slight greenish tinge on the outside, white without any spots inside on the spreading upper half, tinged with yellowish green on the connivent lower half, and covered, except in the center, with minute spots of claret-brown: stamens about 2.5$^{\text{cm}}$ shorter than the perianth; anthers large, linear, brown: stigma [illegible] overtopping the anthers.

Upper Burmah.

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[3] For notes on lily disease see Vt. Exp. Sta. Rept. **11**:297. 1898.

11. L. PRIMULINUM Baker, Bot. Mag. *t. 7227.* 1892.

L. Neilgherrense Coll. & Hem. Linn. Soc. Jour. **28**:138. 1890 (non Wight).

L. Claptonense hort. Low in Baker, loc. cit. 1892.

Bulb large globose, scales lanceolate: stem stiffly erect, 9–12^{dm} high: leaves scattered, lanceolate, erecto-patent, sessile, 7.5–10^{cm} long: flowers about three, on long cernuous pedicels with a large lanceolate leaf at the middle; perianth open funnel-shaped, pale yellow, unspotted, tinted outside with green in an early state, 12–15^{cm} long; segments oblanceolate-oblong, the outer and the inner nearly uniform, above 2.5^{cm} broad at the middle, connivent in an open funnel in the lower half, subrecurved in the upper half: stamens rather shorter than the perianth: anthers linear, brown: style much overtopping the anthers, and reaching to the very tip of the perianth segments.

Upper Burmah.

12. L. NEPALENSE D. Don. Wern. Nat. Hist. Soc. Mem. 3:412. 1820.

L. triceps Klotzsch, Bot. Ergeb. Waldem. Reise. 53. 1845.

L. nanum Klotzsch, loc. cit.

L. ochroleucum Wall. in hb. Lindl. in Baker, Linn. Soc. Jour. **14**:231. 1874.

Stem 3–6^{dm} high, stiff: leaves 30–50, scattered, ascending, lanceolate or linear, distinctly 5–7-nerved: flowers solitary or few, slightly fragrant, nodding, yellowish white more or less tinged with purple, often with small scattered dots inside: segments oblanceolate-unguiculate, reflexed in the upper third, 13–13^{cm} long: stamen less than one fourth the length of the perianth: pollen yellow: capsule ovate, 5^{cm} long.

Temperate regions of western and central Himalayas.

13. L. RUBELLUM Baker, Gard. Chron. III. **23**: 321. 1898.

Bulb globose, with lanceolate scales: stem slender, bearing about 20 alternate, obscurely petioled, bright green, lanceolate leaves, the central ones the largest, about 5^{cm} long, conspicuously

; 7-nerved: flowers one or two, erecto-patent; perianth open funnel-shaped, pink, unspotted, nearly 7.5^{cm} long, 7.5^{cm} in diameter when fully expanded; segments oblanceolate oblong, obtuse, the inner 2.5^{cm} broad, the outer narrower, slightly tinged with green toward the base: stamens less than half as long as the perianth; anthers small, linear, bright yellow: style arcuate, overtopping the stamens.

Japan. Very recently introduced to English and American gardens. Evidently closely related to *L. Japonicum*, and doubtfully held separate from that species.

14. L. Parryi Wats. Davenp. Acad. Proc. **2**: 188. 1886.

Bulb small with jointed scales: leaves linear-oblanceolate, usually scattered: flowers horizontal, pale yellow; segments about 7.5^{cm} long, with spreading or recurved tips: capsule narrowly oblong.

San Bernardino county, California. A pretty species, not uncommon in cultivation.

15. L. Washingtonianum Kellogg, Cal. Acad. Proc. **2**: 13. 1863.

L. Bartramii Nuttall herb. in Baker Linn. Soc. Jour. **14**: 232. 1874.

Bulb oblique, somewhat rhizomatous, with rather small, lanceolate scales: stem $6–15^{dm}$ high: leaves in several whorls of 5–12 each, or sometimes a few scattered, oblanceolate, spreading, sessile, $7.5–10^{cm}$ long: flowers few or sometimes as many as 20, on ascending pedicels, white, tinged with pink or red and dotted with purple, fragrant, rather loose funnelform; perianth segments oblanceolate, gradually narrowing downward, reflexed in the upper third: stamens short; anthers yellow: ovary less than one third the length of the curved style.

California.

Var. purpureum Mast. Gard. Chron. II. **2**: 322. 1874.

L. rubescens Wats. Am. Acad. Proc. **14**: 256. 1879.

Smaller and more slender, with smaller more pinkish flowers, and perianth segments less acute.

16. L. PHILADELPHICUM Linn. Sp. Pl. 435. 1762. [Ed. 2.]

L. Pennsylvanicum Gawl. Bot. Mag. **22**: *t. 872.* 1805.
L. dauricum Gawl. Bot. Mag. **30**: sub. *t. 1210.* 1809.
L. andinum Nutt. in Fraser. Cat. 1813.
L. umbellatum Pursh. Fl. 1: 229. 1814.
L. spectabile Link. Enum. Hort. Berol. 1: 321. 1821.
L. verticillatum Willd. in Kunth. Enum. Pl. **4**: 263. 1843.
L. Catesbæi hort. Bouch. in Kunth. op. cit. 264. 1843.
L. Philadelphicum wansharaicum hort. in Duch. Soc. Hort. Par. Jour. II. **5**: 49. 1871.
L. montanum Nelson, Torr. Bot. Bull. **26**: 5. 1899.

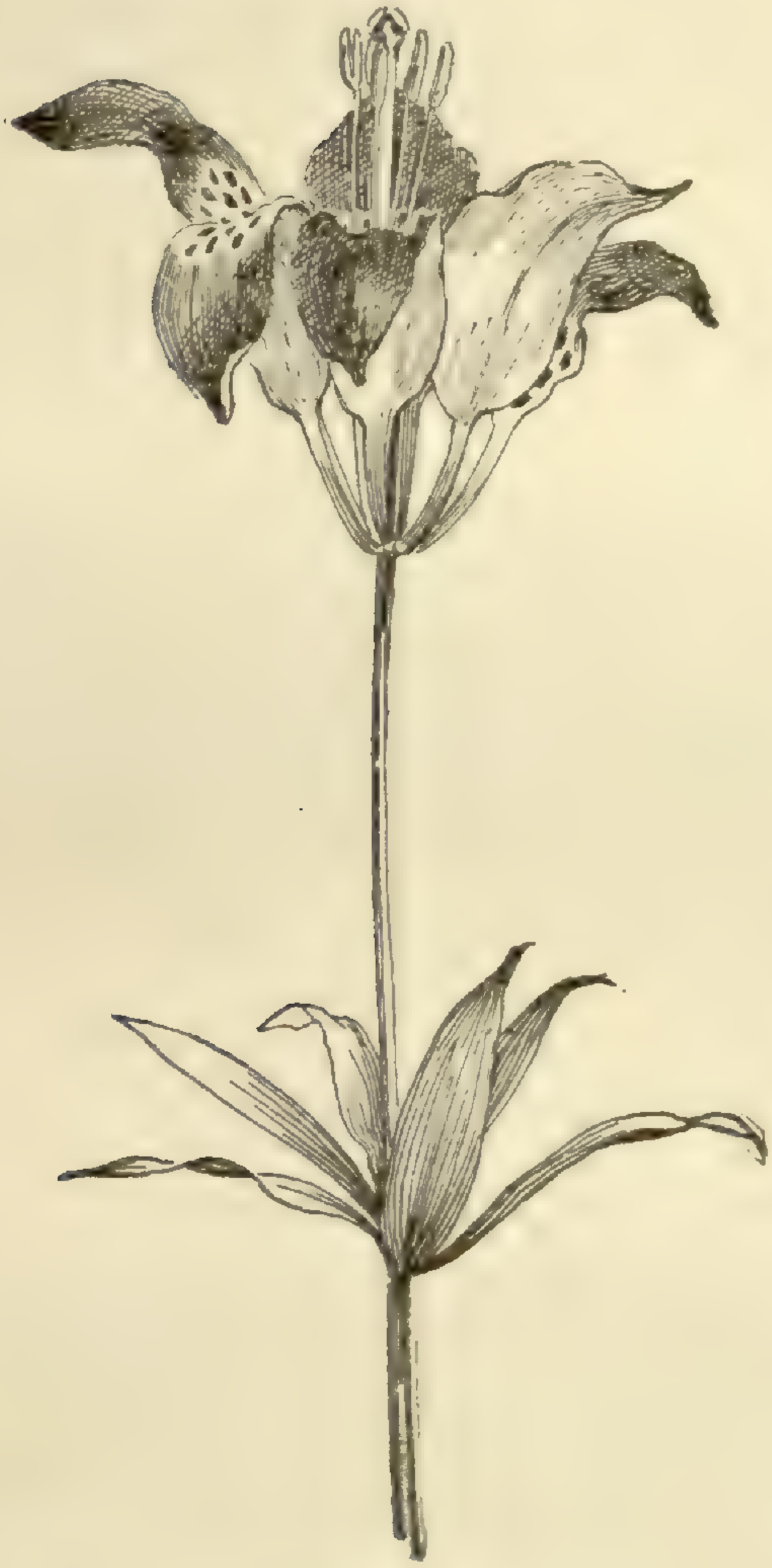

FIG. 3.—Lilium Philadelphicum.

Bulb annual, rhizomatous, small, with few thick, brittle scales: stem 3–9^{dm} high, slender: leaves 10–40, lanceolate or linear, thin, glabrous, finely nerved, usually more or less whorled: flowers 1–4, terminal or umbellate, bright red, marked with large scattering purplish spots toward the center; segments 5–7.5^{cm} long, long clawed, oval above: stamens less than one third the length of the perianth; pollen red: ovary about half as long as the style: capsule narrow, obovoid.

From Canada to North Carolina and west to the Rocky mountains.

17. L. MEDEOLOIDES Gray. Am. Acad. Mem. **6**: 415. 1857.

L. Canadense Thunb.? Fl. Jap. 204. 1784.

Stem slender, 3–6^{dm} high: leaves several, often crowded in a single 7–14-foliate whorl, sometimes partly scattered. obov ceolate, thin, glabrous: flowers 1–3, with short erect pedicels, open funnel-shaped, bright orange-red with a few spots within; segments lanceolate, slightly recurved from the base, thickened at the tip: ovary clavate, a little shorter than the straight style.

Japan, Korea.

18. L. CONCOLOR Salisb. Parad. Lond. *t. 47.* 1806.

Bulb perennial, ovoid, small, with few oblong, acute scales: stem slender, 3^{dm} or more high: leaves 20–30, ascending, scattered, lanceolate, $5–7.5^{cm}$ long, obscurely 7-nerved: flowers 1–3, erect; perianth $2.5–5^{cm}$ long, spreading, bright scarlet, unspotted, with segments lanceolate, thickened at the tip: pollen red: ovary clavate, deeply grooved; style clavate, very short.

China. One of the very best species for garden culture.

Var. SINICUM Hook. Bot. Mag. II. **28**: *t. 6005.* 1872.

L. Buschianum Lodd. Bot. Cab. *t. 1628.* 1825–33.
L. sinicum Lindl. in Paxt. Fl. Gard. 2, misc. 115, *t. 193.* 1851.
L. concolor Buschianum Baker, Linn. Soc. Jour. **14**: 236. 1874.

Taller, with larger bulb, flowers rather more numerous, perianth segments a little wider, bright scarlet with small black spots.

Southern Siberia.

Var. PULCHELLUM Baker, Linn. Soc. Jour. **14**: 237. 1874.

L. pulchellum Fisch. in Mey. Ind. Sem. Hort. Petrop. **6**: 56. 1839.

A slender yellow flowered variety, perhaps belonging with the next.

Var. PARTHENEION (Sieb. & DeV.) Baker, Linn. Soc. Jour. **14**: 237. 1874.

L. partheneion Sieb. & DeV., Tuinbow Fl. **2**: 341. 1855.
L. coridion Sieb. & DeV. loc. cit.

A fine yellow flowered variety, though scarcely differing from the species in any other respect.

19. L. DAVIDI Duch. in Elwes, Mon. Lil. *t. 24.* 1877.

Bulb unknown: stem erect, slender, about 8^{dm} high: leaves

60–70, crowded toward the center of the stem, linear, 10–13 long, acuminate, hardly narrowed at the base, edges revolute, one nerve at back, covered with short hairs: pedicels 5–7.5 long, with a lanceolate bract at the base, very spreading, slightly cottony at the upper end; flowers in the only known specimen 3, color apparently orange, with numerous purplish spots; perianth segments 3–3.5$^{\rm cm}$ long, oblong, flower wide-spreading but not revolute, with prominent papillae at the base, with a median greenish band on the outside covered with long white hairs: filaments 2.5$^{\rm cm}$ long, suberect; ligulate anthers 1$^{\rm cm}$ long; pollen yellow: style twice as long as the ovary.

Eastern Thibet.

20. L. FORMOSUM, Franchet Jour. Bot. **6**: 313. 1892.

Nearly 1$^{\rm m}$ high, slender: the upper leaves narrowly lanceolate, slender acuminate, three-nerved, narrowed into a short petiole: flowers one or two, erect; perianth full white, cup-shaped: segments oblong-lanceolate, 15–17$^{\rm cm}$ long, opening but little at the tips, obtuse, densely pubescent on the inside at the base: stamens a little shorter than the perianth, with short anthers; pollen yellow: style slender, much longer than the ovary; capsule obovate, widely truncate at the tip, 5$^{\rm cm}$ long.

Eastern Su-tchuen, China.

21. L. BULBIFERUM Linn. Sp. Pl. 302, ex parte. 1753.

L. humile Miller, Dict. n. 4. 1768. [Ed. 8.]
L. scabrum Moench. Meth. 305. 1794.
L. elatum Salisb. Prod. 237. 1796.
L. pubescens Bernh. in Hornem. Hort. Hafn. **2**: 962. 1807.
L. Sibericum Schlecht. Enum. Hort. Berol. Suppl. 17. 1813.
L. latifolium Link. Enum. Hort. Berol. **1**: 321. 1821.
L. purpureo-croceum Bosc. in Steud. Nom. 480. 1821. [Ed. 1.]
L. aurantiacum Sieb. in Loud. Hort. Brit. Suppl. **2**: 645. 1830.
L. lancifolium hort. Bouch. in Kunth. Enum. Pl. **4**: 364. 1843.
L. sanguineum hort. in Lindl. Bot. Reg. *t. 50*. 1846.
L. Wilsoni hort.? in T. Moore, Flor. et Pomol. 192. 1868.
L. atrosanguineum hort. in Vil. Fl. Pl. Terre, 629. 1870. [Ed. 3.]
L. biligulatum hort. in Baker, Hort. Soc. Jour. N. S. **4**: 43. 18[illegible].
L. lateritium hort. in Baker, loc. cit.

Bulb ovoid, perennial, with a few wide acute scales: stem 6–12$^{\mathrm{dm}}$ high: leaves scattered, 7–5$^{\mathrm{cm}}$ long, the upper ones often bearing bulbils in the axils: flowers one to many, umbellate or somewhat racemose, on short stout pedicels; perianth 5–6$^{\mathrm{cm}}$ long, erect spreading, bright red or dark orange, usually with some dull spots, papillose toward the center.

Central Europe. Long cultivated in gardens. Many horticultural varieties have been named, but no form seems to be sufficiently marked to justify separate treatment.

22. L. CROCEUM Chaix in Vill. Hist. Pl. Dauph. **1** : 322. 1786.
L. bulbiferum DC. Fl. Fr. **3** : 202. 1805.
L. aurantiacum Dum. de Cours. Bot. Cult. **2** : 1972. 1811. [Ed. 2.]
L. aurantium Haw. in Loud. Hort. Brit. Suppl. **2** : 645. 1830.
L. pumilum hort. Bouch in Kunth. Enum. Pl. **4** : 265. 1843.

Bulb perennial, globose, with large, ovate-lanceolate scales: stem 6–15$^{\mathrm{dm}}$ high, vigorous: leaves numerous, crowded, linear or lanceolate, 7.5–10$^{\mathrm{cm}}$ long, 3–5-nerved, glabrous, never bearing bulbils in the axils: flowers solitary or 10–15 in an umbellate raceme; pedicels ascending, 5–7.5$^{\mathrm{cm}}$ long, white cobwebby; perianth erect, wide funnelform, 5–6$^{\mathrm{cm}}$ long; segments oblong-lanceolate or ovate-lanceolate, narrowed into a short claw, bright orange, conspicuously lamellar-papillose: pollen red.

Switzerland, France, northern Italy. Closely related to *L. bulbiferum*. Much cultivated, especially in Europe.

23. L. ELEGANS Thunb. Acad. St. Petersb. Mem. **3** : 203. 1811.
L. Philadelphicum Thunb. Fl. Jap. 135. 1784 (non. Linn.).
L. bulbiferum Thunb. Linn. Soc. Trans. **2** : 333. 1794 (non. Linn.).
L. Thunbergianum Schultes f. Syst. Veg. **7** : 415. 1830.
L. aurantiacum Paxt. Mag. Bot. **6** : 127. 1839.
L. atrosanguineum Sieb. in Loud. Hort. Brit. Suppl. **2** : 645. 1839.
L. fulgens Morren in Spae Mem. Gen. Lis. 29. 1845.
L. venustum Kunth, Fl. d. Serr. **7** : 33. *t. 657*. 1851.
L. sanguineum hort. in Vil. Fl. Pl. Terre 499. 1866. [Ed. 2.]
L. hæmatochroum Lemaire, Ill. Hort. **14** : *t. 503*. 1867.
L. alternans Sieb. in Duch. Soc. Hort. Par. Jour. **4** : 215. 1870.
L. umbellatum hort. in Baker, Linn. Soc. Jour. **14** : 239. 1874.
L. davuricum Gawl. in Baker, op. cit. 238.

L. aurantiacum hort. Krelage in Baker, op. cit. 239.
L. pictum hort. Sieb. in Baker, op. cit. 239.
L. Wilsoni hort. in Baker, op. cit. 240.
L. coruscans hort. in Baker, loc. cit.
L. Batmanniæ Wallace, Garden **15** : 396. 1879.

Bulb perennial, ovoid: stem 3^{dm} high or less, stiff, erect, slightly cobwebby or nearly glabrous: leaves 20–30, scattered or crowded, ascending, firm, dark green, distinctly 5–7-nerved, lanceolate: flowers 1–5, spreading funnel-shaped, usually solidly colored in some brilliant shade of yellow, orange, or red; segments spatulate, nearly smooth: capsule obovoid, 5^{cm} long.

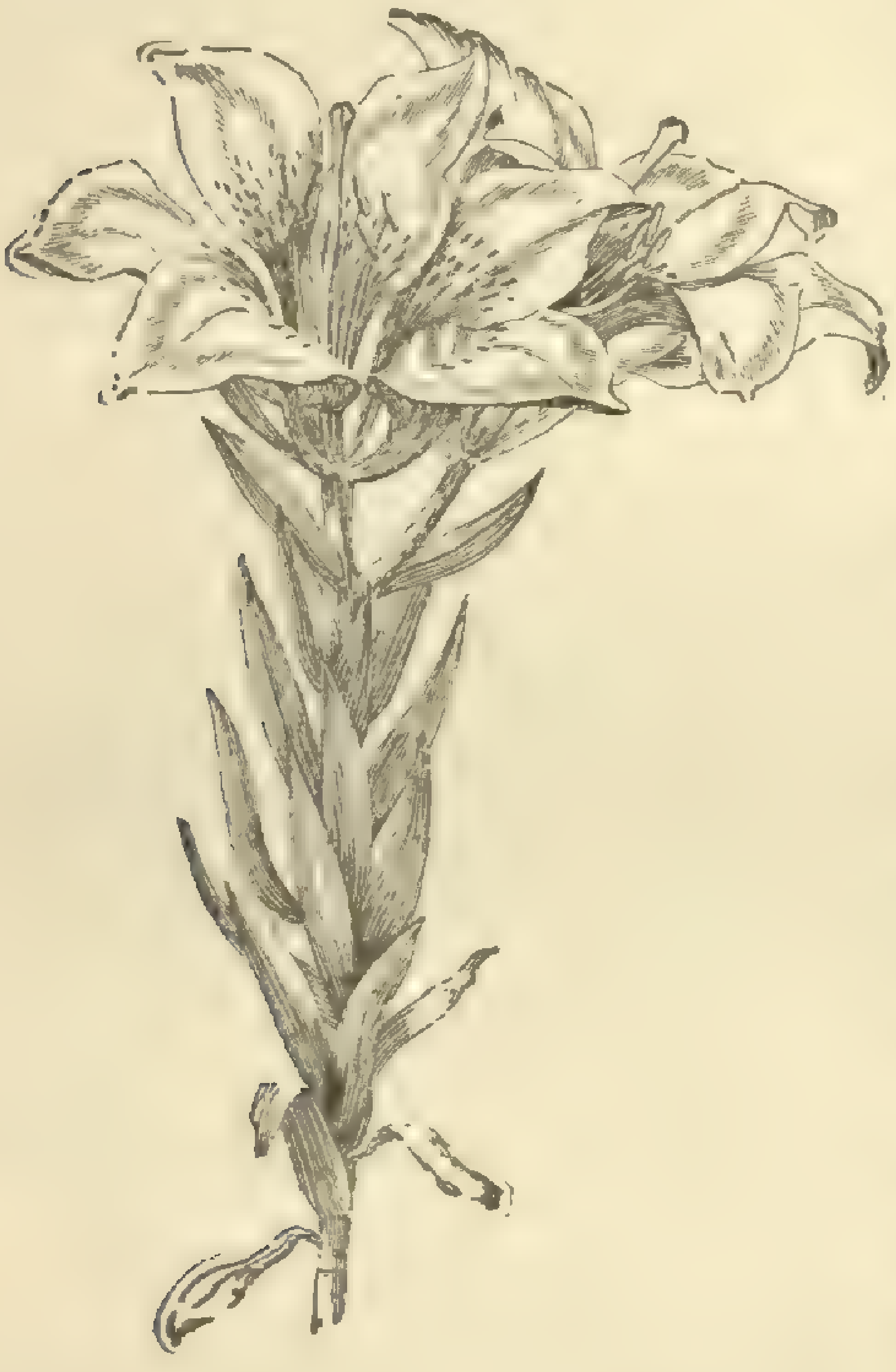

FIG. 4.—Lilium elegans.

Japan. One of the most useful species known to the gardener. Very variable, numbering many striking garden varieties, of which the following are the most notable: var. FULGENS Baker (*L. fulgens*, *L. Batmanniæ*, and *L. sanguineum*, see above), a fine orange-red with somewhat narrowed segments; var. ATROSANGUINEUM Baker & Dyer, a very deep [illegible] red; var. ALUTACEUM Baker & Dyer (*L. armeniacum*, var. *citrinum*, etc.), more or less clear yellow; var. BICOLOR Moore, yellow at the center and reddish [illegible]wards; var. PLENUS, nom. nov., more or less double; var. WALLACEI, nom. nov. (*L. Wallacei* Baker, *ubi?*), small, dwarf, usually one-flowered, [illegible] pale red, perianth segments somewhat acute.

24. L. MYRIOPHYLLUM Franchet, Jour. Bot. **6** : 313. 1892.

Bulb of *L. longiflorum*: stem $1-2^{m}$ high, not rarely bearing bulbils in the axils of the leaves (and then not flowering), [illegible] at the base, foliage crowded quite to the top of stem (leaves easily more than 200): leaves linear or lanceolate-linear, 1-nerved, very acute, with the margin revolute: flowers more often [illegible] erect, with short peduncles, white tinged with green on the outside, full, opening cup-shaped; segments oblong, obtuse scarcely expanded at the tip; the nectar furrow very wide and very smooth, even to the margin: stamens a little shorter than the perianth, with short anthers and yellow pollen: style three times longer than the ovary.

Yun-nan, China. M. Franchet says of this: "Magnificent species, recalling *L. Wallichianum* Schultes by its numerous linear leaves; but easily distinguished from it by the characteristics of its rhizome, its erect flowers, and the enlarged perianth."

25. L. CATESBÆI Walt. Fl. Carol. 123. 1788.

L. Carolinianum Catesby (non Michx.) Car. **2**: *t. 58.* 1733.
L. spectabile Salisb. (non Link.) Stirp. Rar. *t. 5.* 1791.

Bulb like that of *L. Philadelphicum:* stem 3–6^{dm} high, slender, erect: leaves 20–30, scattered, lanceolate or linear-lanceolate, 5–7.5^{cm} long: flowers usually solitary, erect, wide funnel-shaped, 5–10^{cm} broad, bright orange-red marked with scattered purplish dots: perianth segments oblong-lanceolate with long attenuate tips, a grooved claw, and revolute margins: style slender, twice as long as the ovary.

North Carolina to Florida and west to Kentucky. A very pretty plant, but does not succeed in cultivation, at least not in the northern states.

26. L. BAKERIANUM Collet & Hemsley, Linn. Soc. Jour. **27**: 138. 1890.

Stems 9–12^{dm} high, two-flowered: leaves alternate, thickish, narrow linear, nerves obsolete: flowers white, erect, long pedunculate, campanulate, about 10^{cm} long and broad; segments of the perianth unequal, contiguous, slightly recurved, base broad, spotted, inner surface naked: stamens less than half the length of the perianth.

Shan hills, India, at 1200^{m} altitude. Not yet known in cultivation.

27. L. TIGRINUM Andr. Bot. Rep. **9**: errata. 1809.

L. pomponium Lour. Fl. Cochinch. 207. 1790.
L. speciosum Andr. (non Thunb). Bot. Rep. *t. 586.* 1797–1804.
L. sinense hort. in Steud. Nom. **2**: 44. 1840. [Ed. 2.]
L. Fortuni Lindl. Gard. Chron. **1862**: 212.

L. Leopoldi hort. in Baker, Linn. Soc. Jour. **14**: 233. 1874.
L. erectum Baker, loc. cit.

Bulb perennial, globose, with oblong-lanceolate, acute scales: stem 6–15^{dm} high, somewhat whitish cobwebby: leaves scattered, rich green, ascending, linear, 7.5–10^{cm} long, 5–7-nerved, the upper leaves shorter and bearing bulbils in their axils: flowers 3–10, or sometimes more, in a wide raceme, nodding, bright red, thickly spotted with large purplish spots; perianth segments lanceolate-acuminate, strongly twisted revolute, papillose on the claw: filaments scarlet, anthers black, pollen scarlet: ovary half as long as the much curved style.

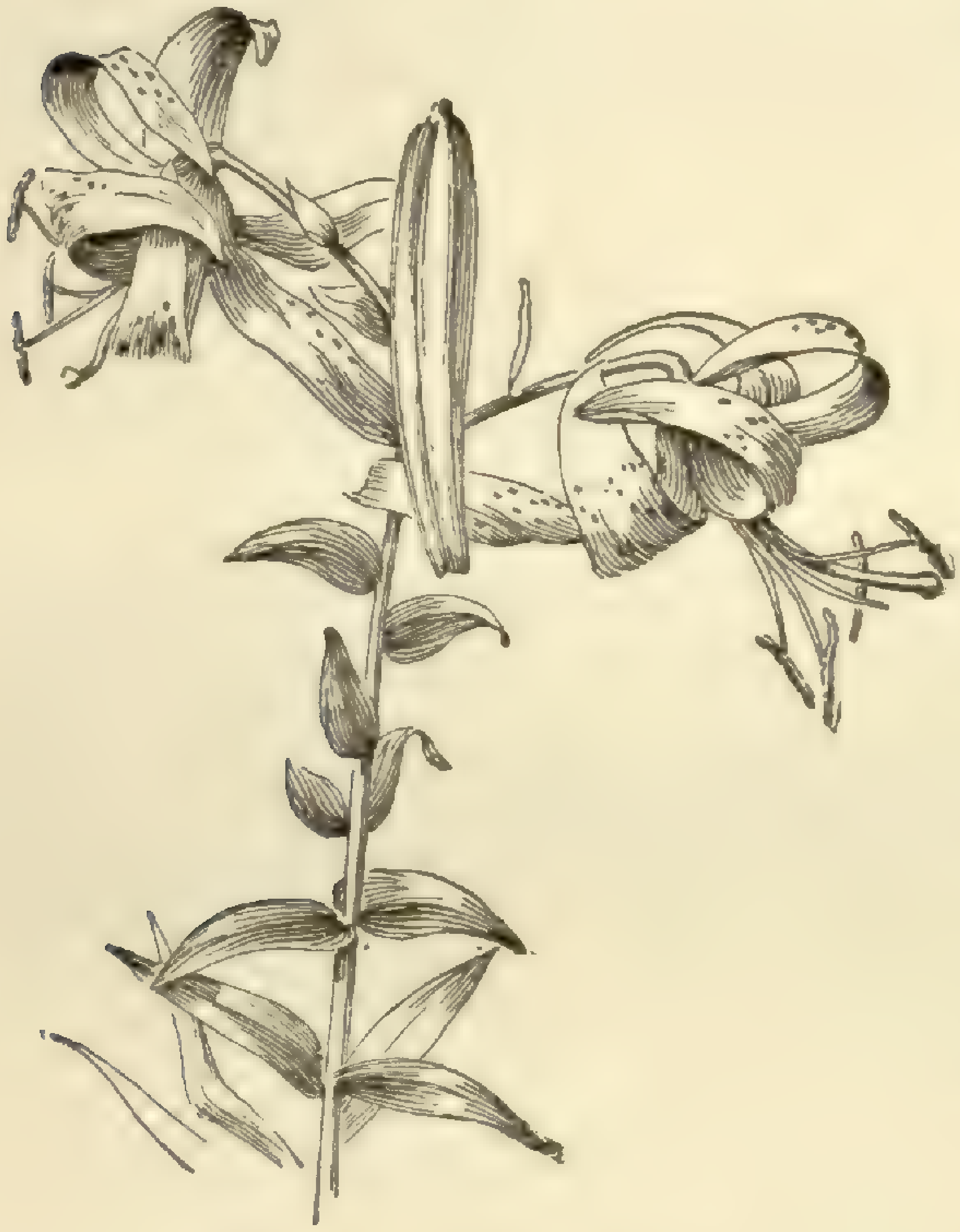

FIG. 5.—Lilium Tigrinum.

Japan and China. An old-fashioned garden favorite, and one of the best lilies for general culture, especially in the var. *splendens*.

Var. SPLENDENS Leicht. in Van H. Fl. d. Serr. **17**: 130. [illegible]

A fine garden variety of more robust habit than the species, with long flowering spikes.

Var. PLENESCENS, nom. nov.

An odd double variety grown in collections.

Other garden varieties are to be referred without confusion to the species.

BURLINGTON, VERMONT.

[*To be concluded.*]

SOME APPLIANCES FOR THE ELEMENTARY STUDY OF PLANT PHYSIOLOGY.

W. F. GANONG.

(WITH FIGURES 1–7.)

THE enlargement of the bounds of knowledge in any science, though primarily dependent on the researches of specialists, is greatly aided by a wide diffusion of their results through proper teaching. Thus are public sympathy and support enlisted, while the greater number of students attracted allows of wider selection and hence better material for the development of new investigators. This is all true of plant physiology, but at this particular time there is an additional reason for attention to it. Elementary botanical teaching is at present being improved to the point of reorganization, and the advance is chiefly in the direction of the study of the plant alive and at work, and of the interpretation of plant-structure through plant-function. This necessarily involves experimental plant physiology, the chief obstacles to whose wide introduction are the expense and difficulty of making it a laboratory study. The greatest service that can be rendered to the advancement of botanical teaching at the present time seems to me the invention of simpler, more manageable, less expensive and more logically conclusive experiments for demonstrating the most fundamental facts and principles of plant-physiology. This is as legitimate a subject for investigation as any other, and one whose difficulty and the ultimate scientific value of whose results give it no mean rank.

Most of the purchasable physiological appliances have been invented by investigators for obtaining results of a precise quantitative character, and are usually cumbrous. complicated, and expensive. An investigator can afford to use nothing less than the best, but in elementary teaching, where it is chiefly qualitative results that are sought, great simplification in appliances should be possible. No doubt when the stimulus of a wide use in teaching shall direct the proper combination of physiological knowledge and inventive skill more extensively in this direction, astonishingly simple ways of demonstrating important facts and principles will be found. Much has already been done along this line, but every teacher knows that many of the apparently simple experiments of the books are not actually practicable, nor do they always cover the more important topics. Just here, indeed, lies the kernel of the whole matter; it is not only practicable experiments that are wanted, but experiments upon the most fundamental topics, absorption, transfer, transpiration, photosynthesis, respiration, growth, irritability. One good experiment upon such themes is worth many upon minor ones. No doubt the subject will ultimately work itself out for elementary classes in much the same way that it has already done in physics, namely, in the form of a standard series of a dozen or fifteen experiments on the leading topics, the apparatus for which will be purchasable at a fair cost from supply companies.

The appliances here to be described have been developed in the author's courses in Smith College. Every piece has been many times tried and is known to be practicable.

1. A temperature stage.

The response of protoplasmic movement to variations of temperature, even if not a topic of much importance in itself, is worth studying as a fine example of quantitative response to external influences, and especially as an introduction to the exact statistical method of studying physiological phenomena. It is not, of course, for beginners, but for those of middling grades. For this work a temperature stage is necessary, preferably one for each student; but those on the market cost from $7 upwards. An efficient stage that can be made by any plumber at small cost is shown in *fig. 1*. It is of sheet copper, one-sixteenth of an inch thick, of the breadth of a microscope stage, rolled over as shown by the figure to make a chamber for a thermometer and another for a three-inch slide, with holes for the light. Forward it dips down to enter a shallow (one inch deep) tin box which hangs from it by one cross wire and two stubs, as in the figure. Both stage and box taper forward to one inch and one and one half inches respectively, a feature not necessary though it diminishes leverage when the box is full. A battery clamp, properly filed, holds the apparatus to the stage of the microscope, and a mat of felt between prevents conduction of heat to it. The ordinary thermometers necessary for other purposes about a laboratory may be used, or bent ones, more easy to read, may be obtained at little advance over the straight kind. To raise the temperature, the box is filled with water and heated by a spirit lamp; to lower it, the box is filled with ice and salt. Every degree of temperature may thus be obtained, from below zero to boiling. If the student, observing stamen-hairs of Tradescantia or Nitella, uses an eyepiece micrometer and a metronome ticking seconds, the rate of movement under each degree of temperature may be obtained with the greatest nicety. The

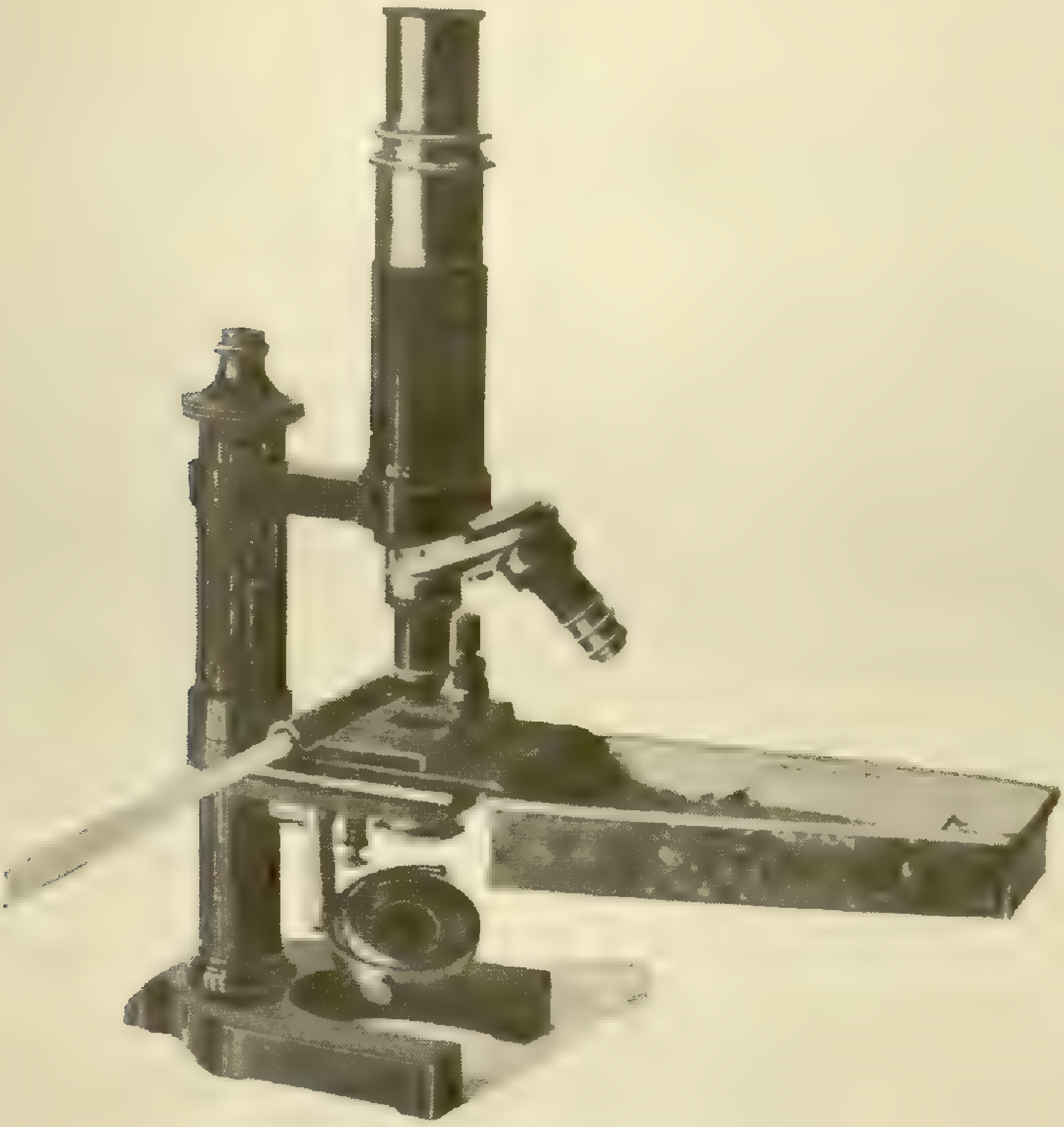

FIG. 1.—A temperature stage.

minimum, optimum, and maximum may be determined precisely, and all results tabulated and plotted in curves, an exercise of great pedagogic value to those beginning exact work in physiology.

It may be thought that the thermometer, being further from the source of heat than the slide, may register a lower temperature. This, however, is not appreciably so, as shown by one stage I had made with thermometer chambers both proximal and distal of the slide chamber. In this both thermometers registered practically alike unless the temperature was being raised with great rapidity, which is in any case not permissible because of its abnormal effects upon the protoplasm.

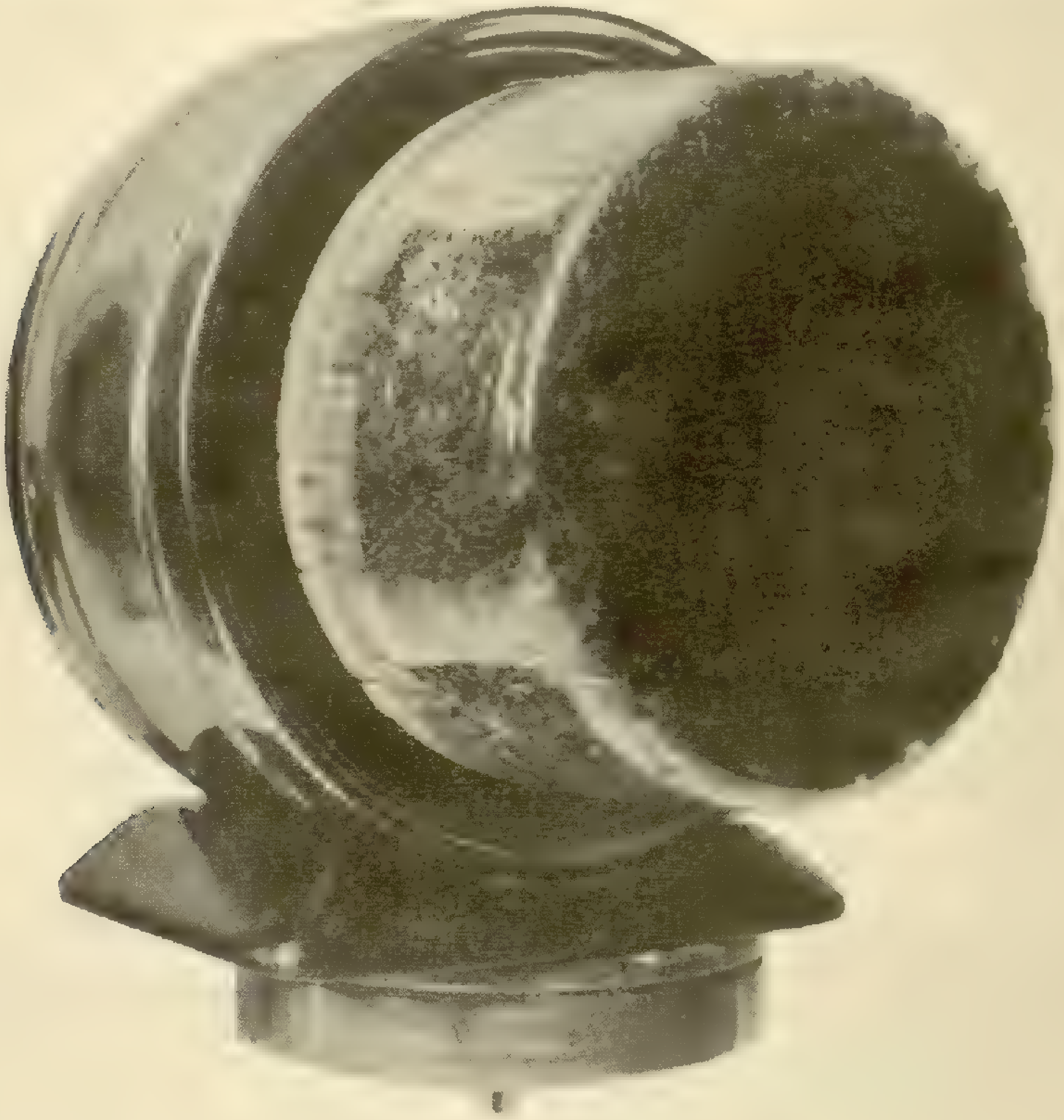

FIG. 2.—A clinostat.

2. A clinostat.

It is most astonishing that so vastly important and illuminating a subject as irritability should receive so little attention as it does in our elementary courses. It is the clearness and ease with which this and some other fundamental biological phenomena may be illustrated in plants that makes botany, properly used, an indispensable factor for training in biology. Very much can be done in its illustration with no appliances at all, though for the satisfactory demonstration of some of its most important phases, a clinostat is necessary. The cheapest clinostat on the market is Wortmann's, costing $50, a very efficient instrument. Where, however, as in elementary work, it is the *principle* of geotropism or heliotropism that is to be illustrated, and not their manifestations in some particular plants or their parts, the arrangement shown in *fig. 2* is ample. A Seth Thomas eight-day clock is altered by a clockmaker so that its minute hand revolves once in fifteen minutes (to keep within ordinary reaction time).[1] The hands and surplus wheels are removed, and over the spindle thus left a brass sleeve is fitted, bearing at its outer end a thin brass disk, two inches in diameter, with a few holes in its edge, revolving in a plane parallel to the clock face. When the clock is horizontal this disk will carry a small flowerpot and when vertical it will carry also a considerable weight though hardly a pot. For illustrating geotropism, one takes two corks about five inches in diameter and an inch thick and pins to each of them soaked beans in the five different extreme possible positions; each is then covered with damp chopped sphagnum moss which fills a thin crystallizing dish of a size to cling to the beveled edge of the cork over which it is firmly pressed. The seeds should be brought out to the heads of the pins nearly an inch from the cork. One of the corks is now fastened to the brass disk by tacks put through the holes in the edge of the latter and is kept revolving in a vertical plane on the clinostat. The other near by, under the same external conditions, is kept fixed in one position. In three days the results are most instructive, and, indeed, this experiment leaves nothing to be desired in the beauty of its illustration of this particular subject.

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[1] I believe that in my instrument this was accomplished partly by shortening the hair spring, and partly by removing each alternate tooth from the escapement wheel.

The best beans I have found for the purpose are horse beans, which are little liable to mold, while chopped sphagnum moss is the best medium I have found for growing seeds in almost any physiological experiments. The entire apparatus costs less than ten dollars.

3. A self-recording auxanometer.

The study of growth in the higher plants, and of how it is influenced by external conditions of light, temperature, moisture, etc., is always an important topic in an elementary course, and for it a self-recording auxanometer is needed. Many forms have been devised, but none has come into general use, except the well-known Albrecht form, which costs over $100. I have made a fair instrument, shown in *fig. 3*, constructed as follows: Take a dollar clock and remove hands, face and all surplus wheels, which will leave a round steel spindle three-fourths of an inch long projecting above the works. Have turned on a lathe a hardwood cylinder, twelve inches long and an inch in diameter, with a hole turned in one end truly in the center, a little smaller than the steel spindle of the clock. The cylinder is then forced down on the spindle and stands vertically and firmly, revolving once an hour. Have turned also on a lathe a double wheel as shown in the figure, the larger as thin as possible, six inches in diameter, grooved on the edge, and the smaller an inch in diameter, the whole carefully and lightly varnished with shellac to prevent warping. Through the axis of this double wheel a small smooth hole is turned on the lathe and by this hole the wheel turns on a clean new fine needle soldered horizontally to a firm support. The wheel will revolve on the needle with very slight friction. A fine silk thread carefully and finely waxed (to prevent hygroscopic absorption of water) is attached in the usual way to the tip of a vigorously growing part (such as a flower stalk of hyacinth), run several times around the small wheel, and fastened by a tiny drop of glue. A similar thread is run in reverse direction around the larger wheel twice and fastened. The other end carries the pen against the cylinder. The pen is made from a piece of small glass tubing sharply bent so that both ends press against the cylinder, one end being open and smoothed and the other drawn out to a capillary point bent to press at right angles against the cylinder.[2] It is then partly filled with chronograph ink. The cylinder is covered with thin smooth paper put on moist with one edge gummed down so that when dry it is without wrinkles. Enough weight is added to the pen to make the wheel turn as the plant grows, and as growth occurs the pen descends, tracing on the paper a spiral line. If now a vertical line be ruled on the cylinder, the length of the parts intersected by the spiral line will give the exact growth per hour, of course magnified. If half-hour intervals are needed, another line is ruled 180° from the first, and the paper between the two removed on one side, when the edges may be brought together, giving half-hour intervals. Of course these records may be removed from the cylinder for preservation. There may not be room for pot and clock under the wheel and either they must be put upon different levels, or else the thread from the plant must be run through a fine screw eye or other smooth arrangement as shown in the figure. This instrument is liable to the same errors as

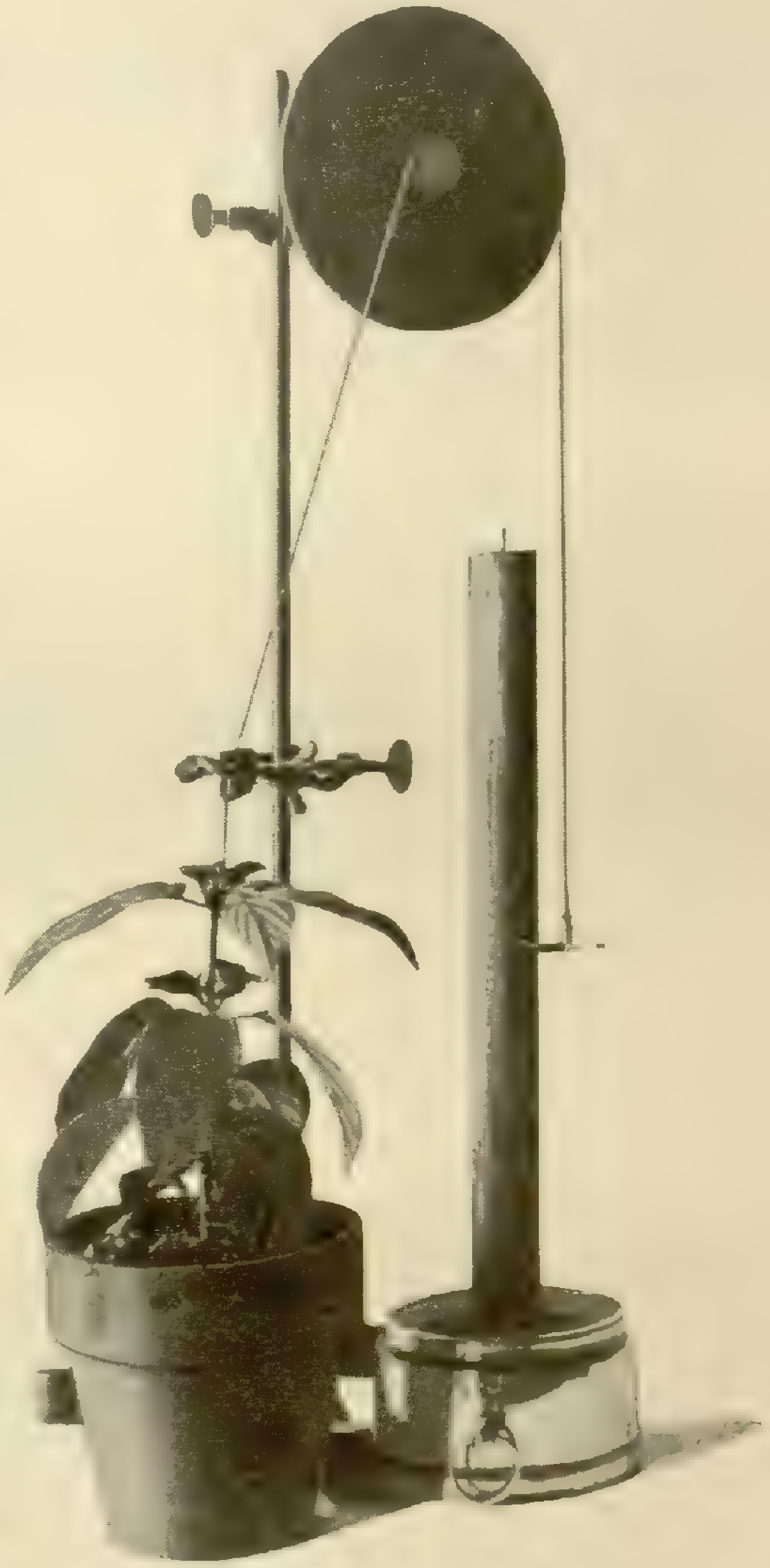

FIG. 3.—A recording auxanometer.

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[2] The figure shows an earlier and less efficient pen.

the Albrecht, but with large vigorous plants it gives results which, if not exact, are sufficiently so to be very instructive to beginners. It need not cost much over $2.

4. An osmometer.

The absorption of water by roots cannot be omitted from an elementary course, and osmosis must be demonstrated, necessitating some form of osmometer. A most efficient one is the following: Cut off an ordinary burette about 2^{cm} below the beginning of the graduation and smooth the end in the flame. Over it push for a centimeter or more a soaked Schleicher and Schüll diffusion shell of 16^{mm} diameter,[3] which will fit the burette exactly, and tie it very tightly with several turns of waxed thread. Fill shell and burette up to the zero mark with molasses, and immerse the shell in pure water. The rise of the liquid will be very pronounced and rapid, and may be measured on the graduated tube.

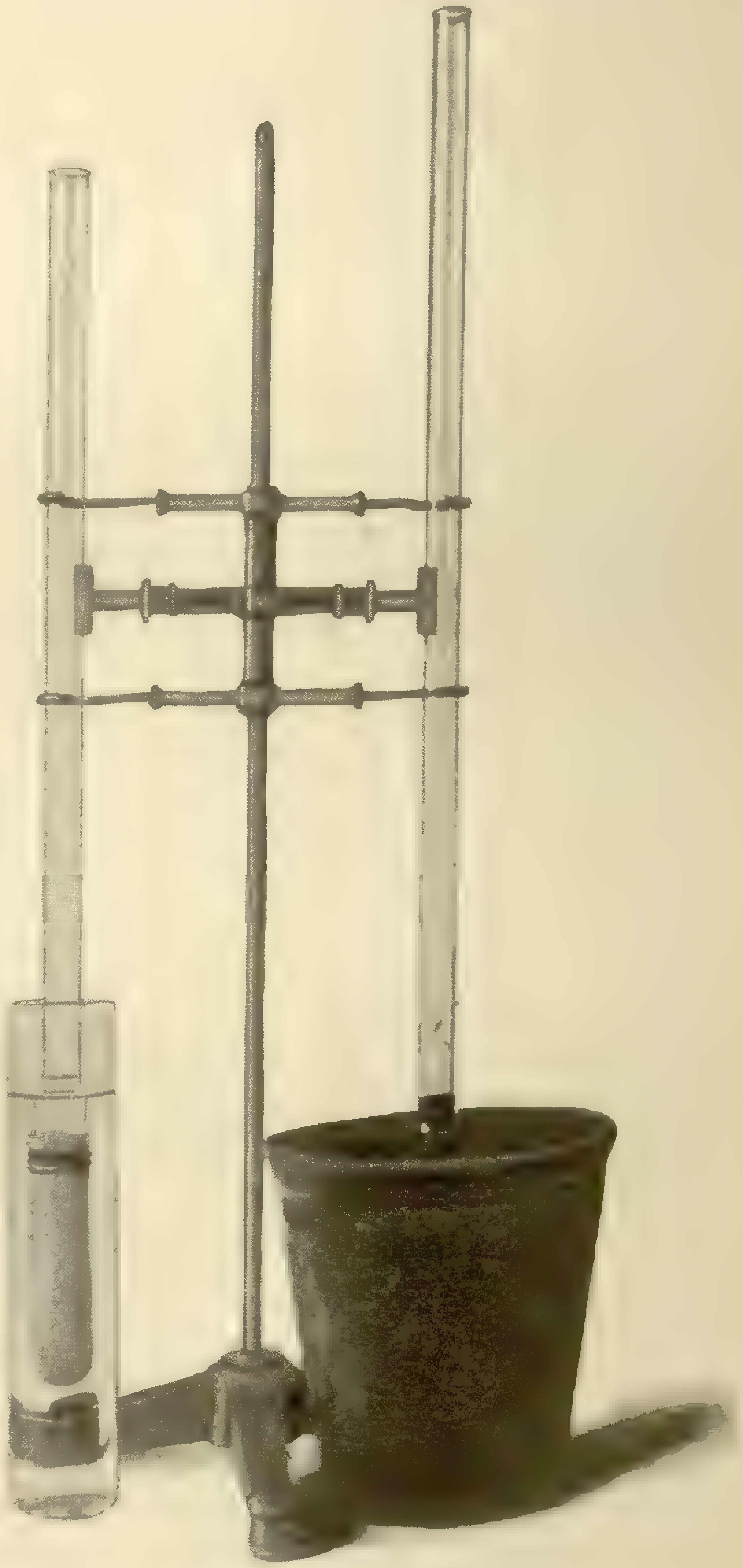

FIG. 4.—An osmometer.

This experiment is most instructive when performed along side of another in which a similar burette is attached by rubber tubing to the cut stump of a vigorous plant with a stem about the diameter of the burette. The water will rise vigorously. We then have side by side two similar burettes, to one of which innumerable tiny absorbing hairs are attached, and to the other a single huge one. It is true there is the difference between them that the root hairs have a semi-permeable lining of protoplasm absent from the shell, and that they do not open directly into tubes as the shell does, but these differences are of minor account in comparison with the fact that it is fundamentally the same physical force that produces the absorption in the two cases.

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[3] These may be obtained at a low cost from Eimer and Amend, New York.

5. A respiration apparatus.

Of prime importance in plant physiology is the exchange of gases in the processes of respiration and photosynthesis. It is the more important in elementary courses, since nearly everybody, with the reciprocal exchange between animals and plants in mind, fails even to recognize that respiration exists in plants. It helps greatly to clear a student's mind on this subject if the nature and importance of respiration are made plain to him before he has had a chance to confound its processes with those of photosynthesis. The germination of seeds offers a good chance to demonstrate the gas exchange in respiration uninflu-

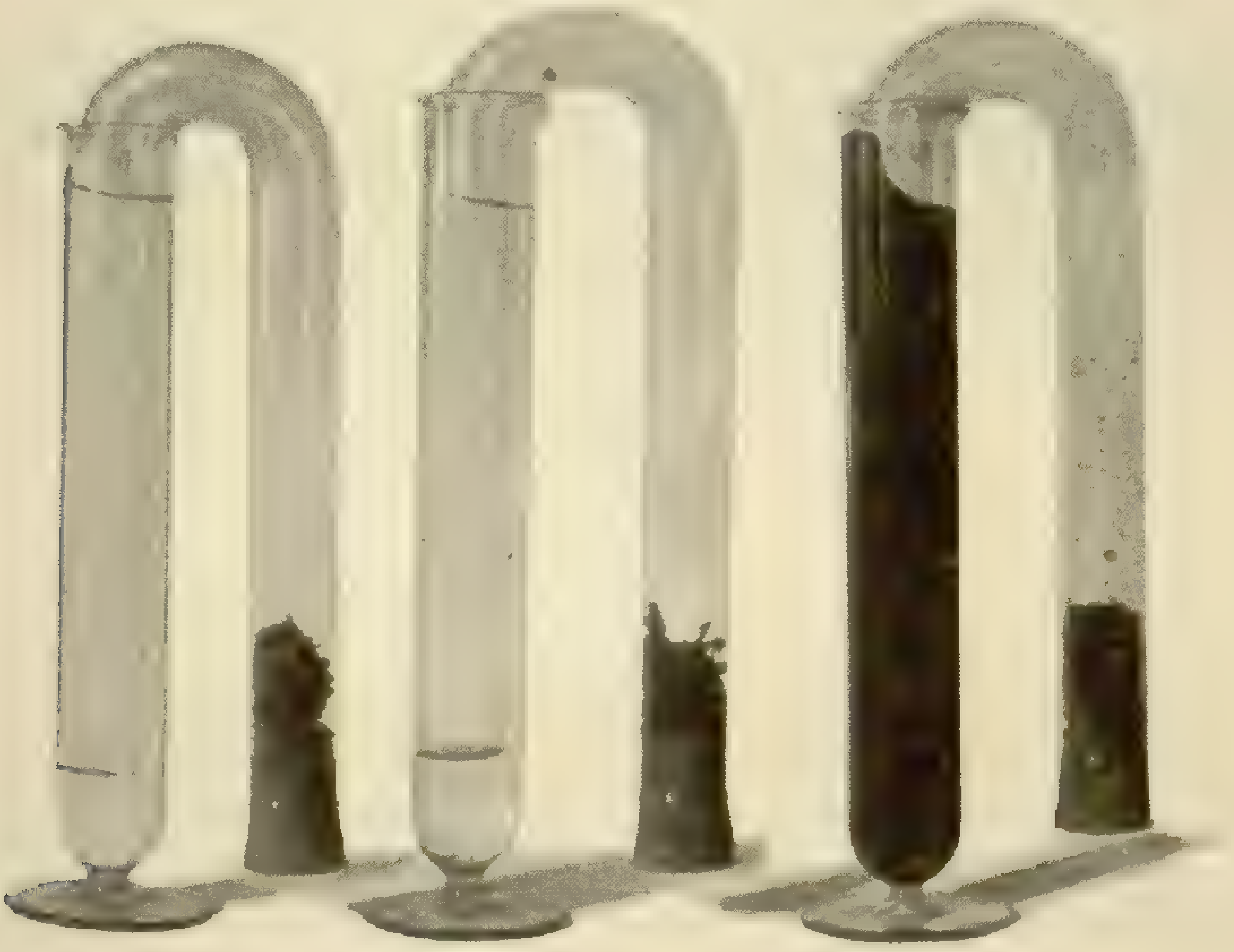

FIG. 5.—Respiration apparatus.

enced by that in photosynthesis, and it may logically be demonstrated as follows:

Take three test tubes on feet (*fig. 5*) or their equivalent, and fill each half full of, respectively, (1) pure water, (2) strong caustic potash, (3) mixture of concentrated caustic potash and pyrogallic acid. Take three U-tubes of somewhat smaller diameter than the test tubes, and in one end of each place about twenty soaked fresh radish seeds, or else a few soaked oats, placing under each lot a wad of moist sphagnum, and shut them in by a tight rubber cork. The other ends of these tubes are to be placed in the three test tubes. It will be found after a few hours that the pyrogallic mixture had risen in the U-tube about one fifth of its length. This is because it has absorbed the oxygen, and it is the most convenient way to get rid of oxygen from a small space. These seeds do not germinate, or only very slightly (probably from intramolecular respiration, though possibly because not all of the oxygen has been removed). In the tube with the potash, in a day or two, the liquid has risen to about one fifth of the length of the U-tube, and the seeds have germinated. The rise is of course due to the absorption by the potash of the carbon dioxide given off by the germinating seeds. In the tube with the water the liquid rises but little though the seeds germinate freely. This part of the experiment is necessary in order to prove that it is not simply the absorption of the oxygen that allows the liquid to rise in no. 2, but that an equivalent volume of another gas is given off.

This experiment logically proves, (1) that oxygen is necessary to growth; (2) that oxygen is absorbed in growth; (3) that carbon dioxide is given off in growth; (4) that oxygen absorbed and carbon dioxide given off in growth are equal in volume. Thus is respiration demonstrated.

In setting up the pyrogallic tube it is practically best to place the pyrogallic acid in the end of the U-tube and the concentrated caustic potash in the test tube. U-tubes, instead of straight tubes with the seeds at the upper end, are best, because in the latter case moisture runs down from the wet seeds and potash diffuses up the streams and kills the seeds.

6. A germination box.

A student's introduction to botany is best made through the study of living plants that are doing something characteristic. Practically it is difficult, and in city schools generally impossible, to make such studies out of doors, and the best substitute I know of is to provide each student at the start with seeds whose germination and growth he can watch. Of course these can be grown in pots or boxes, in sawdust, cotton wool, etc., but after much trial I have found a germination box like *fig. 6*,

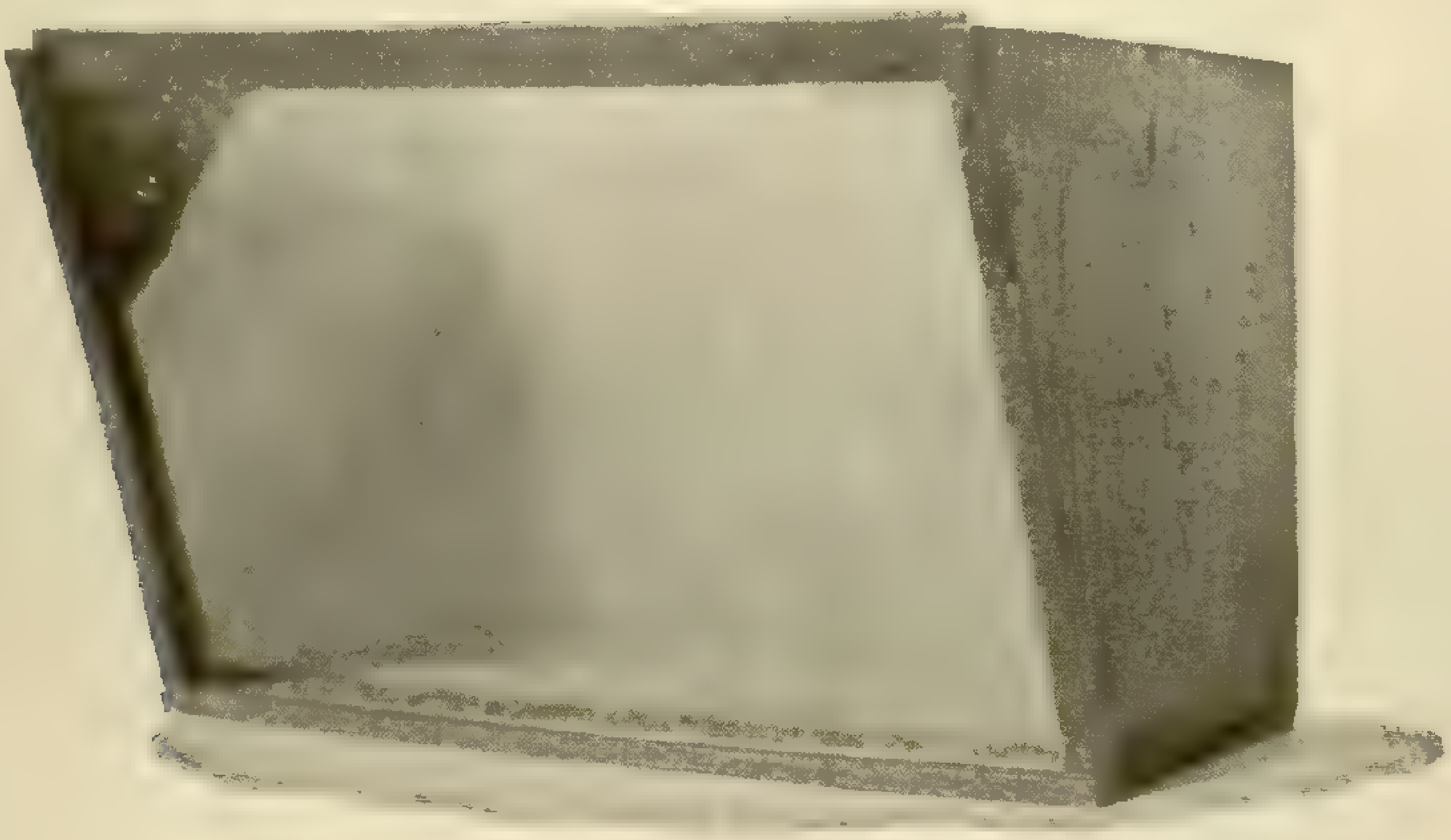

FIG. 6.—Germination box.

filled with chopped sphagnum moss, the best apparatus. It is eight inches in length by six in extreme breadth and five in depth, with a sloping glass side slipping into a groove. The rough edge of the glass is protected by a strip of wood, as shown in the figure. These boxes are made in quantity at box factories for eight cents each without glass, and cost not over twelve cents each complete. When well painted they may be used many years in succession. The great advantage of the sloping glass side is that it allows the roots to be studied, not only the root hairs, and branching, but also their geotropic positions. The latter are particularly instructive when the glass is tipped in the same plane through 45°. In fact, the box is practically the one used to such profit by Sachs. The sphagnum not only permits the seeds to grow well, in this being the best medium I know, but it allows them to be removed without injury to the roots, and it is very clean to work with. The student may keep the same box and follow development of the same seedlings for several weeks.

7. A transpiration device.

In preparing plants for transpiration weighings it is usual to wrap the pot in rubber cloth. This prevents the condition of the pot with respect to water being seen, and limits the supply of oxygen to the roots. If, instead, the pot be placed in a thin glass dish slightly larger in diameter than the pot, and one to two inches higher, it will be necessary only to roof it over with rubber, which is much easier than wrapping the whole plant; the condition of the soil may be seen and more or less water given as seems needed; and the oxygen supply for the roots is more nearly normal. Of course plant and glass are weighed together.

8. The graduation of roots, tubes, etc.

In experiments on growth and geotropism, one often needs to graduate roots, which is done with insoluble India ink. But when the ink is applied with a pen or brush, it generally runs and is very uneven in breadth of the lines. If a fine thread, kept stretched by the spring of a piece of wire, be used, and the ink placed on and allowed to soak into it, marks of perfect evenness and any desired breadth may be made by the thread. It is of course equally good for glass tubes. The thread and spring may be mounted conveniently in a needle-holder. A small frame could be made with threads 1mm apart and parallel, with which a root could be graduated perfectly in one operation.

9. A root-pressure gage.

Root pressure is so important a subject that an efficient gage for its measurement is much needed. None, however, is available; the apparently simple S-shaped tube containing mercury, figured in most books, cannot be made to work without great difficulty. *Figure 7* shows a form which, while liable to some errors, yields, nevertheless, approximately correct results. A tube six inches or less long, with a good glass stop-cock at the top, is graduated, as just described, into convenient small divisions, and is then attached to a stump of a vigorous plant whose stem is about the diameter of the inside of the tube into which it slips a little. The attachment may be made by putting on the stump close to the glass a short piece of rubber tubing about as thick as the glass of the tube; a joint of larger rubber tubing is slipped over the glass and the smaller piece, and is then wound tightly with tire tape which will not yield to pressure from within. Such a joint will be pressure tight. A little water is poured into the tube with a pipette and brought to some zero mark. The stop-cock is then closed. As the water rises in the tube it will compress the air column, and the approximate amount of pressure exerted may be measured by Mariotte's law, *i. e.*, under constant conditions the pressure is inversely proportional to the volume of the air. Of course the successive readings should be taken as nearly as possible at the same temperature. The water vapor in the tube is a source of error, but not an appreciable one if the readings are taken at constant temperatures.

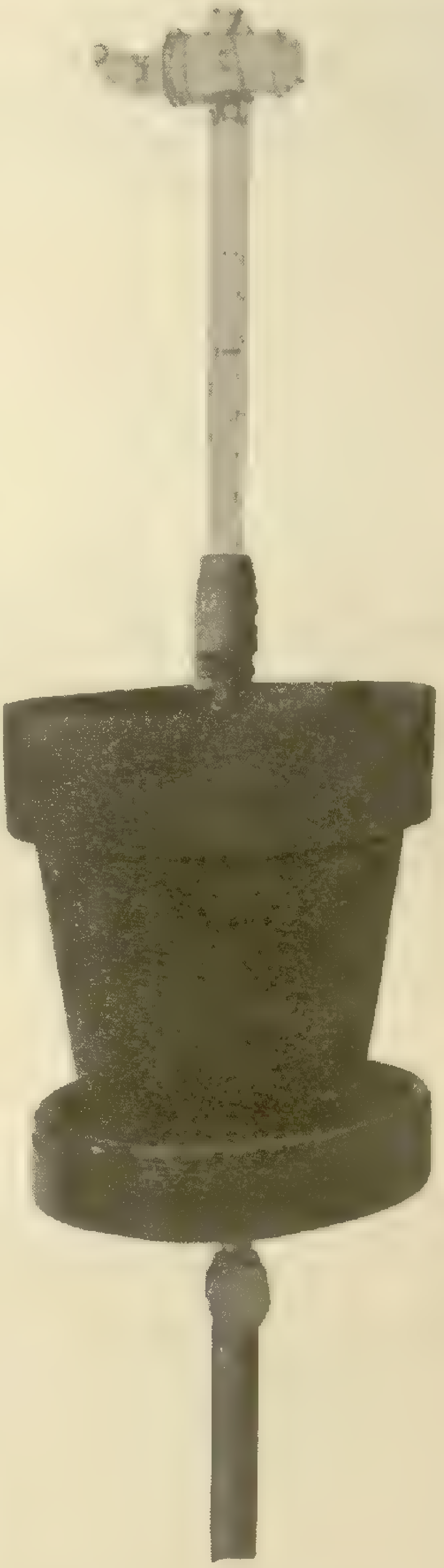

FIG. 7.—Root-pressure gage.

All manometer gages used for such purposes as this are liable to an error not always recognized, in that they assume the *quantity* of water available for exerting pressure to be unlimited, whereas in fact it is always limited. If the plant be small and the gage be large, the plant may not off quantity enough to push the registering fluid up to the which it should reach in order to register the true pressure under which the water actually is given off. Hence these gages are likely to register pressure more accurately the smaller they are.

SMITH COLLEGE, NORTHAMPTON, MASS.

OOGENESIS IN PINUS LARICIO.

WITH REMARKS ON FERTILIZATION AND EMBRYOLOGY.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XIV.

CHARLES J. CHAMBERLAIN.

(WITH PLATES IV–VI)

IN the autumn of 1896, while conducting laboratory work in the special morphology of the gymnosperms, I noticed puzzling peculiarities in the development of the nucleus of the oosphere, but the material lacked important stages and had not been properly fixed for cytological study. The next spring, however, at intervals of three or four days, ovules of *Pinus Laricio* Poir. were collected which gave a fairly complete series from the separation of the neck cell from the central cell of the archegonium up to stages in which the embryos had been thrust through the base of the oospore by the elongating suspensors.

For the earlier stages up to the cutting off of the ventral canal cell, the pair of ovules was merely cut off from the scale and dropped into the killing fluid; for stages from this point to the fusion of the pronuclei, the female gametophyte (prothallium) was usually removed from the ovule to insure rapid killing and fixing. In a part of the material, however, the nucellus was retained to show the course of the pollen tube to the oosphere. In all the later stages the gametophyte was removed from the ovule. All material was fixed on the spot, nothing being taken from cones which had been removed from the tree for more than fifteen minutes. In some cases as many as twenty ovules were taken from a single cone and kept in a separate bottle. These showed almost an identical stage of development. This uniformity occurs also in the sporangia of staminate cones in which the pollen mother cells undergo division at nearly the same time, the sporangia at the base being only slightly more advanced than those at the tip. In the ovulate cone, at the time of the division of the mother cell into potential megaspores, the sporangia at the base are slightly more advanced, but they do not develop much further. For stages figured in this paper, the best material is found in the middle three fifths of the cone.

In my material, all of which was collected in the vicinity of Chicago, the ventral canal cell, in the season of 1897, was cut off about June 21, and fusion of the pronuclei occurred about a week later. In the season of 1896, all stages appeared more than two weeks earlier.

Various fluids were used for killing and fixing. For mitotic phenomena the most satisfactory results were secured by allowing Flemming's weaker solution to act for about two hours and then replacing it by a chrom-acetic solution (0.75^{gm} chromic acid and 0.25^{cc} to 100^{cc} water) in which the material remained for one or two days. In this way the advantages of the Flemming's solution seem to be secured without the objectionable blackening. The chrom-acetic acid used alone gave excellent results. Carnoy's fluid (absolute alcohol 6 parts, chloroform 3 parts, acetic acid 1 part), followed by cyanin and erythrosin, is good for tracing nuclei in the pollen tube and for differentiating the granules and network within the nucleus. Corrosive sublimate-acetic acid could hardly be recommended for achromatic structures in Pinus. Hermann's fluid and Merkel's fluid failed to give as good results as the much less expensive chrom-acetic acid. The popular safranin gentian-violet orange combination gave the most definite stain for achromatic structures-but Haidenhain's iron-alum-haematoxylin used alone, or followed by acid fuchsin, was better for most stages in the development of the oosphere nucleus.

THE VENTRAL CANAL CELL.

No attempt was made to secure a complete series of early stages leading up to the condition represented in *fig. 1*, which shows the nucleus of the central cell just before the division separating the ventral canal cell from the oosphere. At this stage there is often only a single nucleolus, and very seldom more than two or three. This is worth noting, for the oosphere nucleus, soon after the cutting off of the ventral canal cell, contains a very large number of nucleoli. The chromatin is extremely scanty, unless, perhaps, it is in a diffuse state or forms a part of the nucleoli.

The mitotic figure concerned in the cutting off of the ventral canal cell presents a very characteristic appearance. The spindle is strongly developed and the part lying in the oosphere is sometimes quite convex, while the part within the ventral canal cell is concave (*fig. 2.*) The ventral canal cell usually begins to show signs of disorganization almost as soon as it is cut off. In this figure the nucleus had evidently reached the spirem stage before it began to disorganize. A similar difference between the nucleus of the ventral canal cell and that of the oosphere at this stage was noticed in several cases. In *fig. 3* the nucleus had developed further before disorganization set in, for a fully formed nuclear membrane is present and the chromatin is in the form of nucleoli or irregular masses. It is not unusual for the ventral canal cell to become separated from the egg as shown in this figure. In such cases the separation is due to the splitting of the wall between the two cells, and in some cases, even when no separation has taken place, as in *figs. 6* and *7*, the wall can be seen to be double. A later stage is shown in *fig. 5*, in which the ventral canal cell is reduced to a deeply staining mass, probably of mucus-like consistency, in which no structure is discernible. *Fig. 4* represents a ventral canal cell of about the same age as the preceding, but the chromatin is not so abundant and the other cell contents are scanty. It does not seem probable that such a cell, in its later stages, would present the appearance shown in *fig.* 5 or exert such an influence upon the course of the pollen tube as might be expected in the latter case. In both *fig. 5* and *fig. 6*, the nuclear membrane has entirely disappeared and no structure can be made out except that the mass is more or less homogeneous and contains a few nucleoli. That the nucleoli here represent the chromatin is proved by a very complete series, of which only a few stages (*figs. 2, 3* and *5*) are figured.

In later stages it may be difficult to identify the ventral canal cell as a whole, but vestiges of it in one form or another can usually be found up to the time when the pollen tube enters the neck of the archegonium, and occasionally traces may be seen even after the sporophyte is considerably advanced (*fig. 19a.v.*).

While the above account gives the usual history of the ventral canal cell, there are other rather exceptional cases which belong to an opposite course of development and are interesting on account of their bearing upon the homology of the ventral canal cell. *Fig. 7*, which is drawn to the same scale as *fig. 2*, shows an enormous spindle, somewhat loosely attached to the daughter nuclei. This ventral canal cell is eight or ten times as large as the typical one shown in *fig. 2*. It contains several proteid vacuoles like those of the oosphere, and its nucleus is undergoing the usual developmental changes which will be described for the nucleus of the oosphere. In this particular case, the nuclei of the oosphere and ventral canal cell are of nearly the same size and are in the same stage of development. If a pollen tube should enter, it seems reasonable to suppose that fertilization of the ventral canal cell might result. A later stage in such a course of development is represented in *fig. 10*, in which the nucleus has almost reached the condition presented by an oosphere nucleus just before conjugation. In *fig. 8* the nuclei are in about the same stage as in *fig. 7*, but the wall between the ventral canal cell and the oosphere has broken down, leaving both nuclei free in the oosphere. Fragments of the immense spindle are scattered throughout the oosphere. In some of these a strong line represents a part of the cell plate; in others the fibers are drawn into wisps resembling tips of bipolar spindles. A similar case is shown in *fig. 9*, but here the nuclei have nearly reached the size and stage of development shown in *fig. 17*. Still another example is shown in outline in *fig. 19a, v*. In *figs. 8–10*, the nucleus of the ventral canal cell, on account of its more favorable position, would be more likely to secure fertilization than the more remote nucleus of the oosphere. One might suggest that a stage like *fig. 9* represents the two pronuclei within the egg, or that fertilization has already taken place and the two nuclei are the first two nuclei of the sporophyte. While the series shown in *figs. 7, 8*, and *9* affords an answer to such suggestions, it may be added that vestiges of the pollen tube can almost always be detected above the neck of the archegonium until the oospore nucleus has divided two or three times. No evidences of fertilization were visible in these cases, and besides, the upper nucleus is far too large for a male pronucleus just escaped from a pollen tube. If fertilization has not taken place, the second supposition is already excluded; but it may be added that the nuclei are too large for the first nuclei of the sporophyte, they lack the very characteristic appearance of the latter, and, further, their position is against any such interpretation.

The origin of the ventral cell has led several writers to regard it as the homologue of the egg. That this homology is correct the series just described furnishes practically complete proof so far as origin and function can furnish it, the only thing lacking being an actual case of fertilization.

THE DEVELOPMENT OF THE OOSPHERE NUCLEUS.

The development of the nucleus of the oosphere differs decidedly from the usual course of development ascribed to the nucleus of the angiosperm oosphere. After the cutting off of the ventral canal cell, the nucleus of the oosphere increases enormously in size, as will be readily observed by comparing *figs. 2* and *17*.[1] During this increase in size, there takes place in the nucleus a series of changes which for some time it was difficult to interpret. In *fig. 2* the nucleus of the oosphere does not differ much in size or in any other perceptible respect from the nuclei in the sheath about the oosphere. In this figure the nucleus is in a typical spirem stage. The numerous and often coarse radiations about the nucleus were not observed in [illegible] stages of prothallial cells. From this point the development is so extremely rapid that, in over three hundred preparations, less than a dozen nuclei showed stages intermediate between *figs. 2* and *11*. One of these is shown in *fig. 6*, *n. o.* (The proteid vacuoles, *p*, bear a striking superficial resemblance to nuclei.) In this nucleus nearly all the chromatin is in the form of nucleoli. A few linin threads are present, and associated with them is a very small quantity of chromatin. In other nuclei of about the same age, *figs. 7, 8*, no linin is visible, and all the chromatin is in the form of nucleoli. The greater number of these nucleoli stain blue with cyanin and erythrosin, but some stain red. The mere size of the nucleoli has no influence upon these reactions. I have not felt it safe to rely upon staining reactions for identifying chromatin, but have depended upon a close morphological series leading up to undoubted chromosomes. After all trace of the original linin network has disappeared and all the chromatin is in the form of nucleoli, another rather peculiar linin network appears. This and all the nucleoli stain intensely with iron-alum-haematoxylin. At first sight it would seem that we are dealing with a chromatin network, but if the second application of iron-alum be sufficiently prolonged, only a few of the nucleoli remain black, the stain being completely extracted from the network and from the rest of the nucleoli (*fig. 11*). If acid fuchsin be added to such a preparation, the network and the decolorized nucleoli stain red. A later stage, in which the decolorizing has not been carried so far, is shown in *fig. 12*. Details from nuclei in slightly later stages than *fig. 12* are shown in *figs. 14* and *15*, in which nearly all of the nucleoli are arranged upon the linin threads. Soon after this stage, the network begins to resolve itself into a granular substance, thus leaving the nucleoli scattered irregularly throughout the nucleus. Some of the nucleoli contribute to the granular substance, while others migrate from all directions toward a certain point, usually at the center, or a little above the center, of the nucleus. In *fig. 16* the network, while still distinguishable, has begun to break up, and nearly all of those nucleoli which stain black with iron-alum-haematoxylin have taken a characteristic position. Some, however, which do not retain the stain, are scattered through the nucleus. *Fig. 17* shows a somewhat later stage. Only traces of the network are now visible; the granular condition is becoming quite pronounced and the nucleoli are arranging themselves in the form of a ring. The structure within this ring I was not able to make out definitely, but in most cases it seemed to be finely granular, with traces of threads more or less defined.

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[1] All the figures are drawn to the same scale except 14 and 15, and the outline sketches, 9, 19*a*, 24*a*, 25*a*, 26*a*, and 27*a*.

In *fig. 18* every vestige of the network has disappeared, and the nucleus is filled with an evenly granular substance. Nearly all the nucleoli have collected at the center. In *fig. 19* the groundwork of the nucleus shows a beautiful reticular structure, exactly like that of the cytoplasm outside the nucleus. The nucleoli are taking the form of elongated masses which represent definitely the chromatin of the nucleus. The threads seen in the central area are a part of the general reticulum.

The development of the male pronucleus was not studied in detail, but several stages, one of which is shown in *fig. 13*, indicate that the sequence is similar to that just described for the nucleus of the oosphere.

It seems probable that various bodies have been described under the term nucleolus. That some of these nucleoli represent chromatin has been proved both in animals and in plants. In animals the sequence described by Carnoy and Lebrun[2] for batrachians agrees more nearly with the conditions in Pinus. That the chromatin in the resting nucleus of Spirogyra is in the form of a nucleolus has been shown by several investigators, notably by Mitzkewitsch[3]. A chromatin nucleolus is also described by Davis[4] for Corallina, one of the red algæ. A relation between chromatin and nucleoli has been noted in the higher plants, especially by Cavara[5] and very recently by Duggar[6].

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[2] La vésicle germinative et les globules polaires chez les batrachiens. La Cellule 14:113–200. 1898.

[3] Ueber die Kerntheilung bei Spirogyra. Flora **85**:81–124. 1898.

[4] Kerntheilung in der Tetrasporenmutterzelle bei *Corallina officinalis* L. var. *mediterranea*. Ber. d. deutsch. bot. Gesell **16**:266–272. 1898.

Ikeno's[7] figures and description of *Cycas revoluta*, while not dealing with details in the development of the nucleus of the oosphere, nevertheless indicate that the sequence is about as I have described it for Pinus. Blackman's recent work on *Pinus sylvestris* will be considered later. The staining reactions do not seem to furnish a reliable method of distinguishing chromatin nucleoli from other spherical bodies. In thin sections some nucleoli show a sharp differentiation into an outer deeply staining portion and an inner part which stains lightly (*fig. 29*). *Fig. 28* shows a peculiar case. There seemed to be a crack in the nucleolus, and upon applying a gentle pressure the central portion came out from the shell. It might be suggested that the presence or absence of this outer portion, or, when present, its relative thickness, may account in some measure for the reaction to stains. That the staining does not identify chromatin nucleoli is shown by the fact that many of the "nucleoli" in the proteid vacuoles stain intensely black with iron-alum-hæmatoxylin, blue with cyanin, or red with safranin.

FERTILIZATION.

Strasburger's[8] figure of Picea shows conjugating nuclei of equal size. According to Coulter[9], one of the male nuclei in *Pinus Laricio*, after its entrance into the oosphere, increases in size until, at the moment of fusion, it is as large as the female pronucleus. In Ikeno's figures of Cycas, and Blackman's[10] of *Pinus*

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[5] Intorno ad alcune strutture nucleari. Atti del R. Istituto Botanico dell'Università di Pavia 5:1-49. 1897.

[6] On the development of the pollen grain and embryo sac in *Bignonia venusta*. Bull. Torr. Bot. Club 26:89-105. 1899.

[7] Untersuchungen über der Geschlechtsorgane und den Vorgang der Befruchtung bei Cycas *revoluta*. Jahrb. f. wiss. Bot. 32:557-602. 1898.

[8] Befruchtung u. Zelltheilung. Leipzig. 1878.

[9] Notes on the fertilization and embryogeny of conifers. Bot. Gaz. 23:40-43.

[10] On the cytological features of fertilization and related phenomena in *Pinus sylvestris*. Phil Trans. Roy. Soc. of London. B. 190:395-426. 1898.

sylvestris, the male pronucleus is many times smaller than the female. In the present work, although the male pronucleus was often observed within the oosphere, no case was found in which the pronuclei were just coming into contact.

One fine preparation was obtained which shows the chromatin of the two pronuclei within the original limits of the female pronucleus (*fig. 20*). Both pronuclei are in the spirem stage, and show the chromatin granules evenly distributed upon a delicate linin thread. The kinoplasmic threads seem to be developing almost exclusively in the region of the male pronucleus, but it is hardly safe to draw any conclusions. A later stage, which I am not ready to interpret, is shown in *fig. 21*. The spirem thread has become perfectly smooth and has the same diameter as a chromosome in the anaphase of the first division of the fusion nucleus, but the segmentation into chromosomes is not yet complete. It seems possible that the upper group represents the male pronucleus, and the lower the female.

The first division after fertilization (*fig. 22*) shows a beautiful figure with a very strongly developed spindle, some of its kinoplasmic threads reaching from pole to pole while others merge insensibly into the surrounding groundwork of the nucleus. The chromosomes are very definitely U-shaped. After the second division has taken place and the four free nuclei have begun to move toward the base of the oospore, they show a characteristic tangential striation (*fig. 23*) which seems to be caused by a rotation of the nuclei as they descend. In the first division of these four nuclei, after they have reached the base of the oospore (*figs. 24, 24a*), the spindle is extremely broad and multipolar, but in later divisions (*figs. 26, 26a*) the spindle is of the usual bipolar type. This figure gives a typical view of the U-shaped chromosomes as they appear in these divisions, just before becoming separated from each other. Although several early phases of mitosis were found in the nuclei of the partially segmented portion of the oospore (*figs. 25, 25a*), no later stages were obtained. A fairly complete series was obtained showing mitosis in spephytes older than that represented in *fig. 26*. These show that the chromosomes do not resolve themselves into nucleoli, but pass into an ordinary reticulum.

A peculiar monstrosity was noted in one preparation (*figs. 27, 27a*). Instead of the usual free cell formation, each division of the nucleus has been followed by the formation of a wall, so that a somewhat spherical embryo has been formed near the center of the oosphere, about which no trace of a pollen tube could be found.

ARCHOPLASM AND CENTROSOMES.

After the large spindle concerned in the separation of the ventral canal cell from the oosphere has broken up, portions of it become scattered throughout the oosphere (*figs. 8, 19a*). One of these fragments (*19a, s.*) is shown in detail in *fig. 32*. Some of these fragments (*fig. 31, s*) in their later stages show a perfect transition from kinoplasmic fibers to the ordinary reticular structure of the oosphere. Such cases, together with those like *fig. 22*, make it probable that the kinoplasmic fibers do not arise from any specific kinoplasmic or archoplasmic substance but rather from a rearrangement of general reticulum, whether it be outside the nucleus or inside. Such a view, while not popular with botanists, has able supporters among zoölogists.

I was not able positively to identify centrosomes at any time during this work, but in several preparations clearly defined areas resembling the archoplasmic regions in Ascaris were observed near the male nuclei in the pollen tube (*fig. 13.*) The failure to find centrosomes has not convinced me that they are absent from the male nuclei.

The archoplasmic areas shown in *fig. 12* were observed in only one case, although nearly a hundred nuclei in approximately the same stage were examined. These areas, one inside the nucleus and the other outside, are sharply differentiated and are giving rise to rather coarse threads. This is not the usual method of spindle formation for this nucleus and may have nothing at all to do with the spindle.

BLACKMAN'S WORK.

After this paper had been practically completed, there appeared a very important work on *Pinus sylvestris* by Mr. Blackman (*l. c.*) Since this work has already been reviewed in the March number of this journal, only a brief comparison will be made here. I can confirm his statements that the pollen tube does not enter the oosphere; that the pronuclei at the time of fusion are not in the resting condition; that the history of the spindle fibers indicates that they result from a rearrangement of the ordinary cytoplasmic reticulum; and that the number of chromosomes is twelve in the pollen mother cell, in the nuclei of the sheath of the oosphere (*fig. 30*), and in other parts of the prothallium.

My second series (*figs. 7–10*), on the development of the ventral canal cell, was not observed by Blackman. His term maturation is not used, because it already has a definite and very different application. The term metaplasm is not used in the present paper because the network is regarded merely as a somewhat peculiar *linin* network. In the development of the nucleus of the oosphere, he neither figures nor describes the chromatin history in detail, but the points mentioned do not indicate the sequence decribed in this paper. He finds the chromosomes of the first segmentation nucleus V-shaped; *fig. 22* of this paper shows them U-shaped. He figures parallel threads around the four segmentation nuclei; although this appearance was occasionally noted in my preparations, the fibers usually had the arrangement shown in *fig. 23*. On the whole, it must be said that, while the two papers cover approximately the same ground, the more detailed work of each, having been done in different parts of the subject, is complementary. The general results, however, are to a great extent mutually confirmatory.

SUMMARY.

1. While the ventral canal cell usually disappears soon after it is formed, in some cases it persists and its nucleus becomes as large as that of the oosphere, passing through a similar develop-

mental history. New support is thus given to the theory that the ventral canal cell is the homologue of the egg.

2. In the development of the oosphere nucleus the chromatin takes the form of nucleoli which finally collect from all parts of the nucleus to a definite area near the center and there develop into a typical spirem. The linin often stains like chromatin.

3. After the male pronucleus is within the oosphere nucleus, the chromatin of the two pronuclei appears as two distinct masses in the spirem stage. Perhaps segmentation of the two spirems occurs while they are still separate.

4. Although centrosomes were not positively identified in any part of the work, appearances favor the supposition that they may accompany the male nuclei.

5. The fate of the spindle indicates that the kinoplasmic fibers arise through a transformation of the cytoplasmic reticulum.

The University of Chicago.

EXPLANATION OF PLATES IV–VI.

A Zeiss 2^{mm} apochromatic homogeneous immersion objective and compensating ocular no. 4, with camera lucida, were used for all drawings except figs. *14* and *15* (comp. oc. no. 18) and the outline sketches *9*, *19a*, *24a*, *25a*, *26a*, and *27a*, which were made with low power dry lenses. All drawings are reduced one half in photo-engraving.

Abbreviations: *n. o.*, nucleus of oosphere; *n. v.*, nucleus of ventral canal cell; *p.*, proteid vacuole; *s.*, portion of spindle; *v.*, remains of ventral canal cell.

Fig. 1. Nucleus of central cell before cutting off the ventral canal cell.

Fig. 2. Cutting off of the ventral canal cell.

Figs. 3, 4, 5. Three views of the ventral canal cell.

Fig. 6. Apex of the oosphere, showing nucleus of oosphere, proteid vacuoles and the ventral canal cell.

Fig. 7. Extremely large ventral canal cell and spindle connecting it with the nucleus of the oosphere.

Fig. 8. The wall between ventral canal cell and oosphere has broken away, leaving the nucleus of the ventral cell free in the oosphere. Fragments of the spindle scattered through the oosphere.

Fig. 9. Similar to the preceding, but more advanced.

FIG. 10. Ventral canal cell with nucleus developed nearly to the fertilization stage.

FIGS. 11, 12, 16–19. Stages in development of nucleus of the oosphere.

FIG. 13. Two male nuclei in end of pollen tube just as it enters the neck of the archegonium.

FIGS. 14, 15. Nucleoli arranged on linin network; details from nuclei slightly older than *fig. 12.*

FIG. 19*a*. Sketch in which *n. o.* shows position of *fig. 19* and *s* the position of *fig. 32.*

FIG. 20. Fertilization.

FIG. 21. Later stage in fertilization.

FIG. 22. First division of the nucleus of the oospore.

FIG. 23. One and part of another of the four segmentation nuclei showing felt-like covering, with tangential threads predominating.

FIGS. 24, 24*a*. First division of one of the four free nuclei after passing to the base of the oospore.

FIGS. 25, 25*a*. Spirem in nucleus in the partially segmented portion of the oospore.

FIGS. 26, 26*a*. Nuclear figure showing shape of the chromosomes.

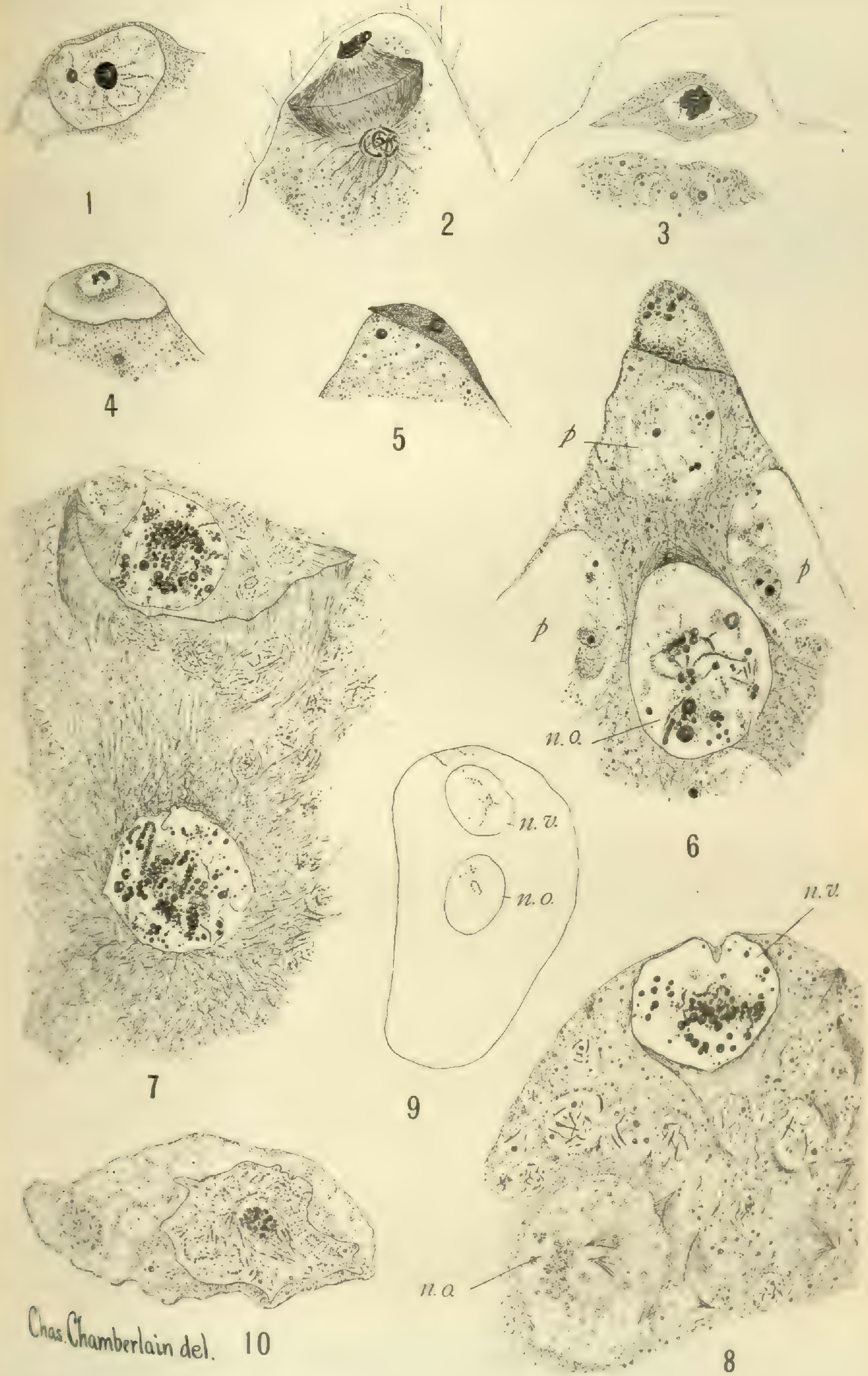
FIG. 28. Nucleolus showing deeply staining outer and lightly staining inner portions.

FIG. 29. Inner portion of nucleolus pressed out from the outer "shell."

FIG. 30. Nucleus of one of the cells sheathing the oosphere, showing the twelve chromosomes.

FIG. 31. Fragments of the ventral canal cell spindle showing transition between spindle fibers and cytoplasmic reticulum.

FIG. 32. Fragment of spindle. See *fig. 19a, s.*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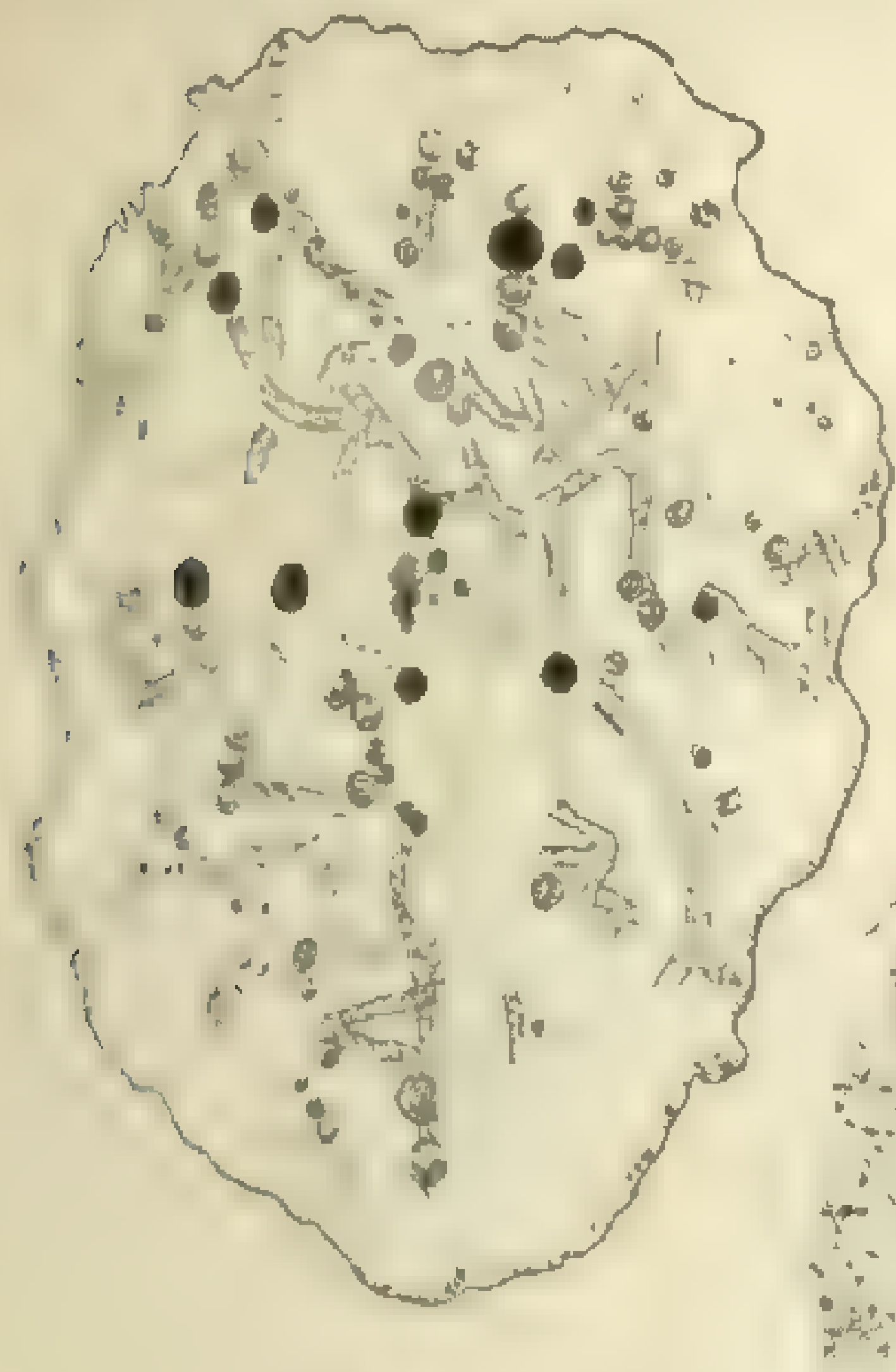
Chas. Chamberlain del.

CHAMBERLAIN on OOGENESIS



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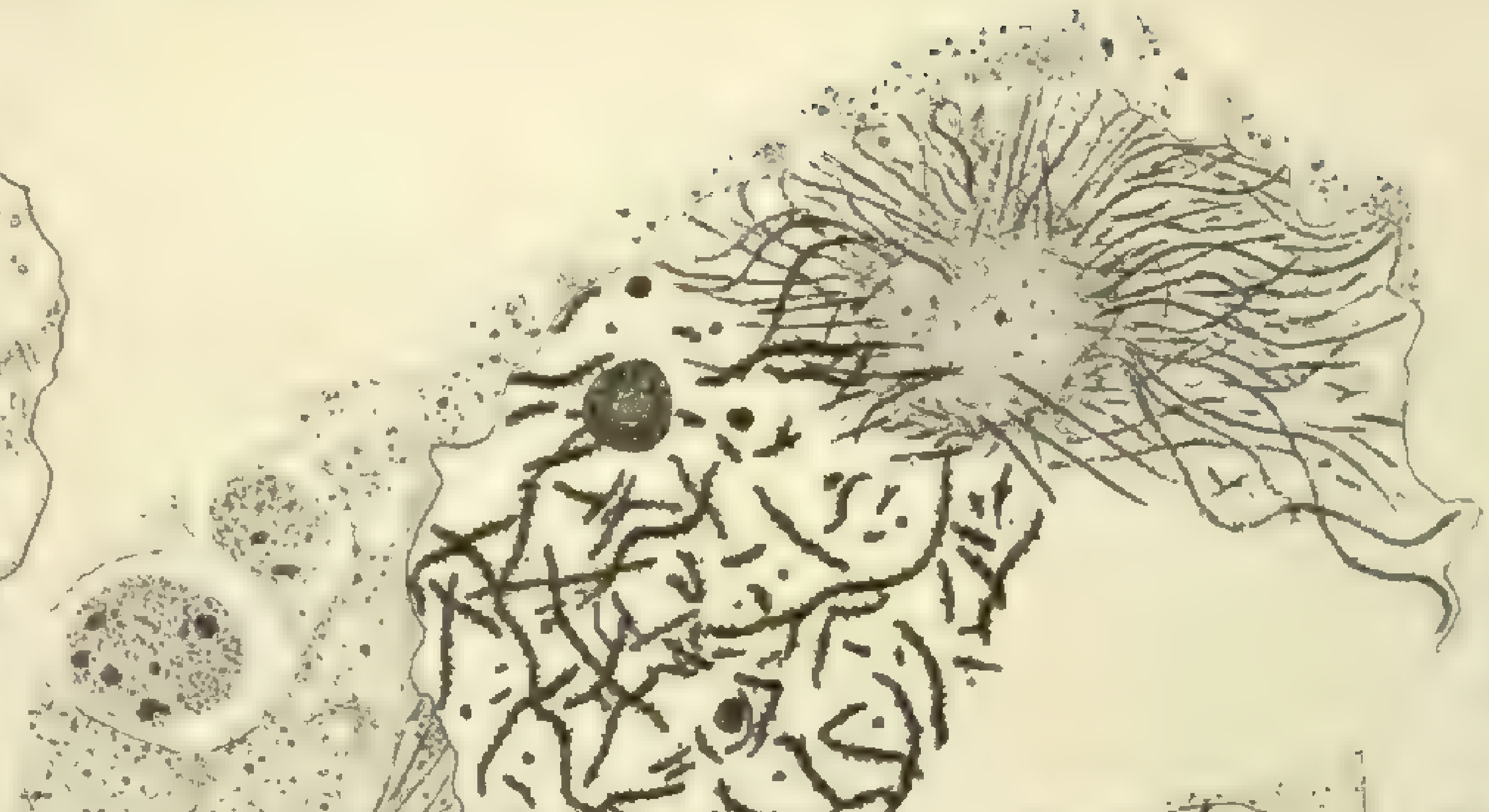

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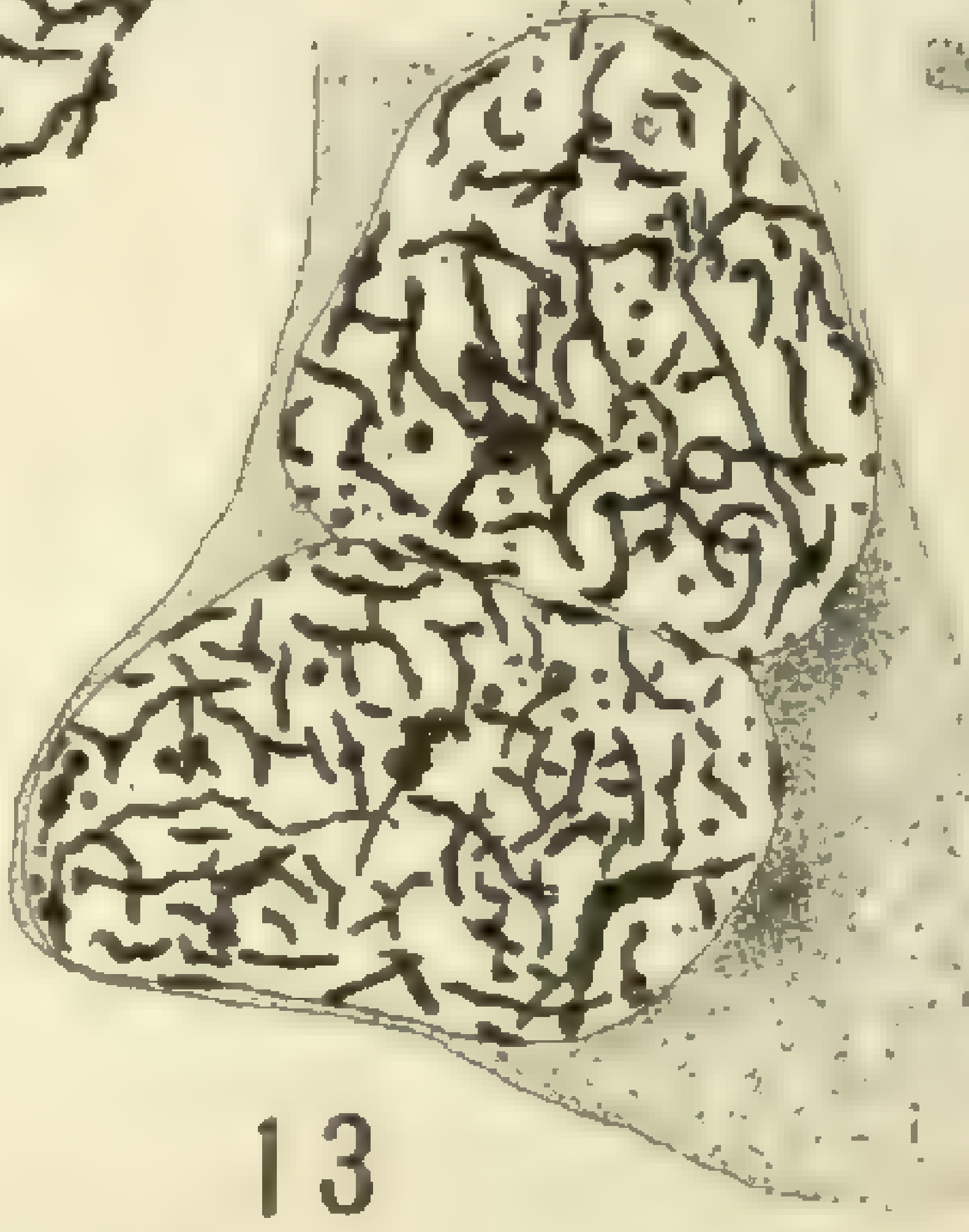

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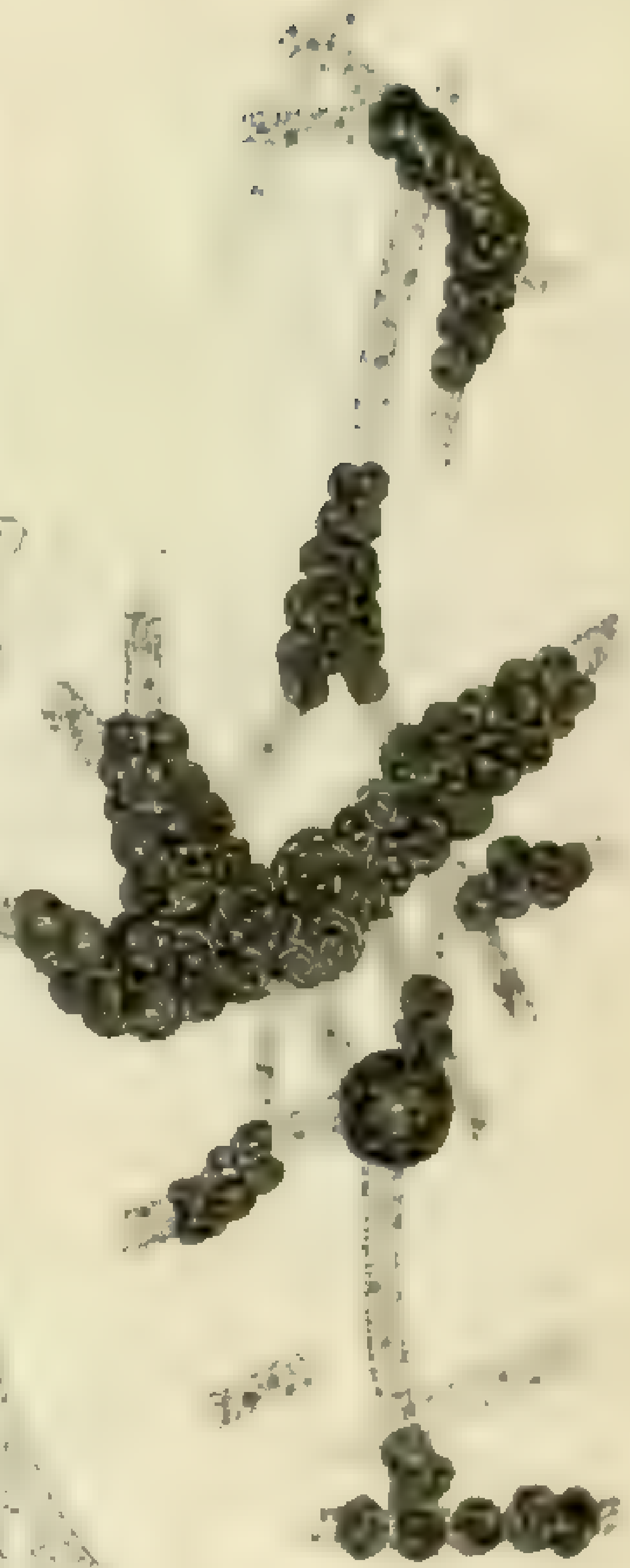

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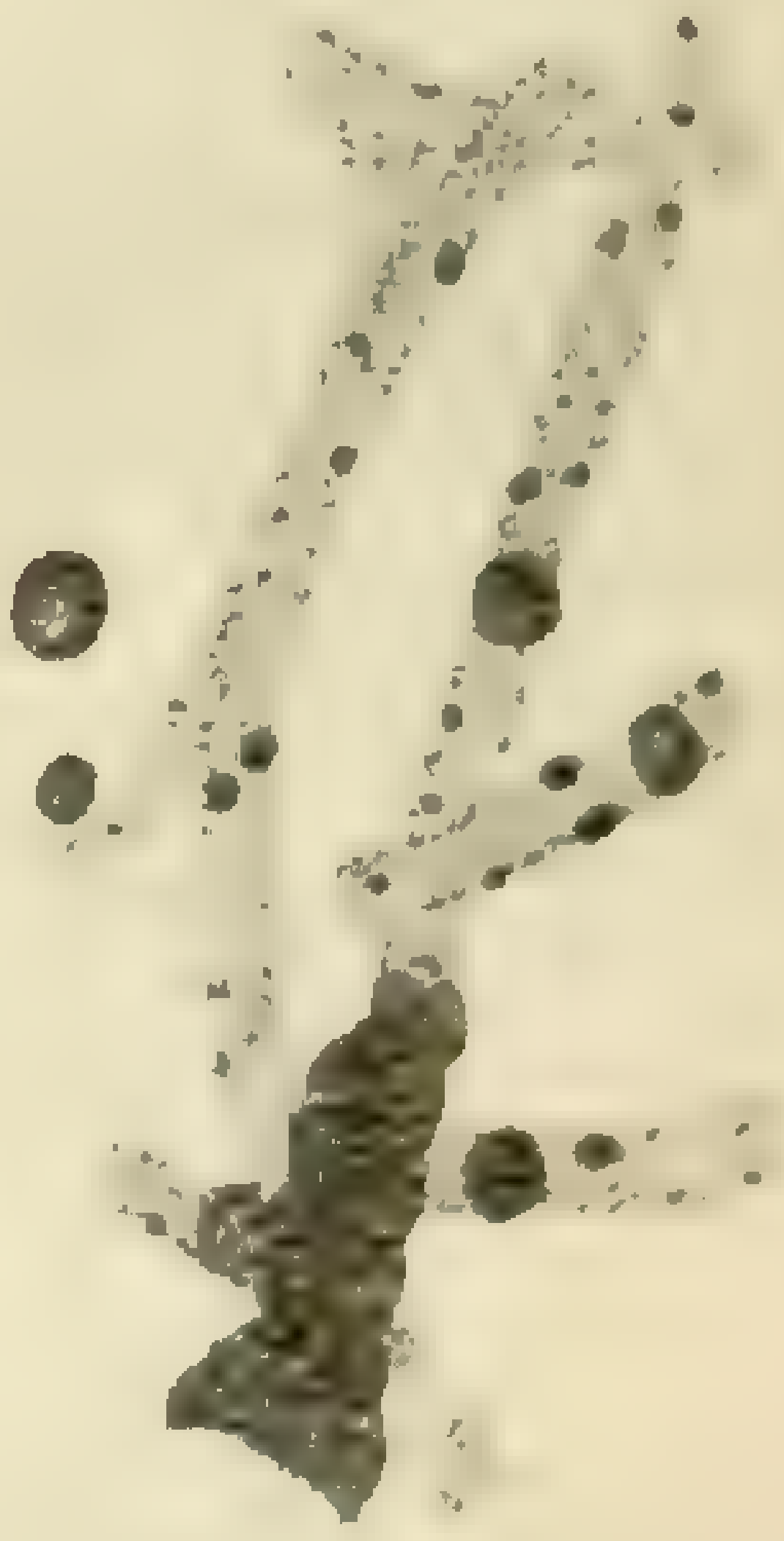

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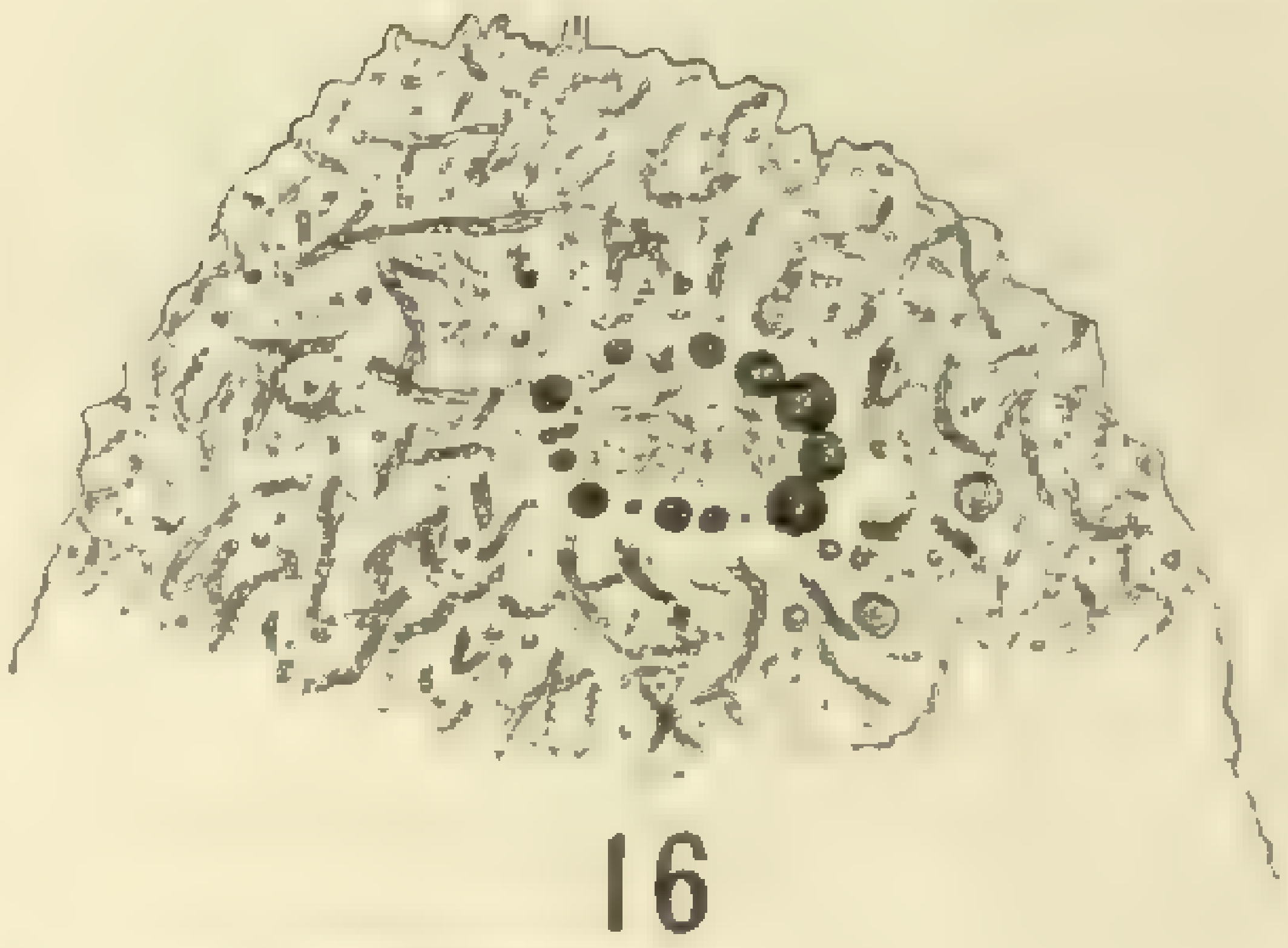

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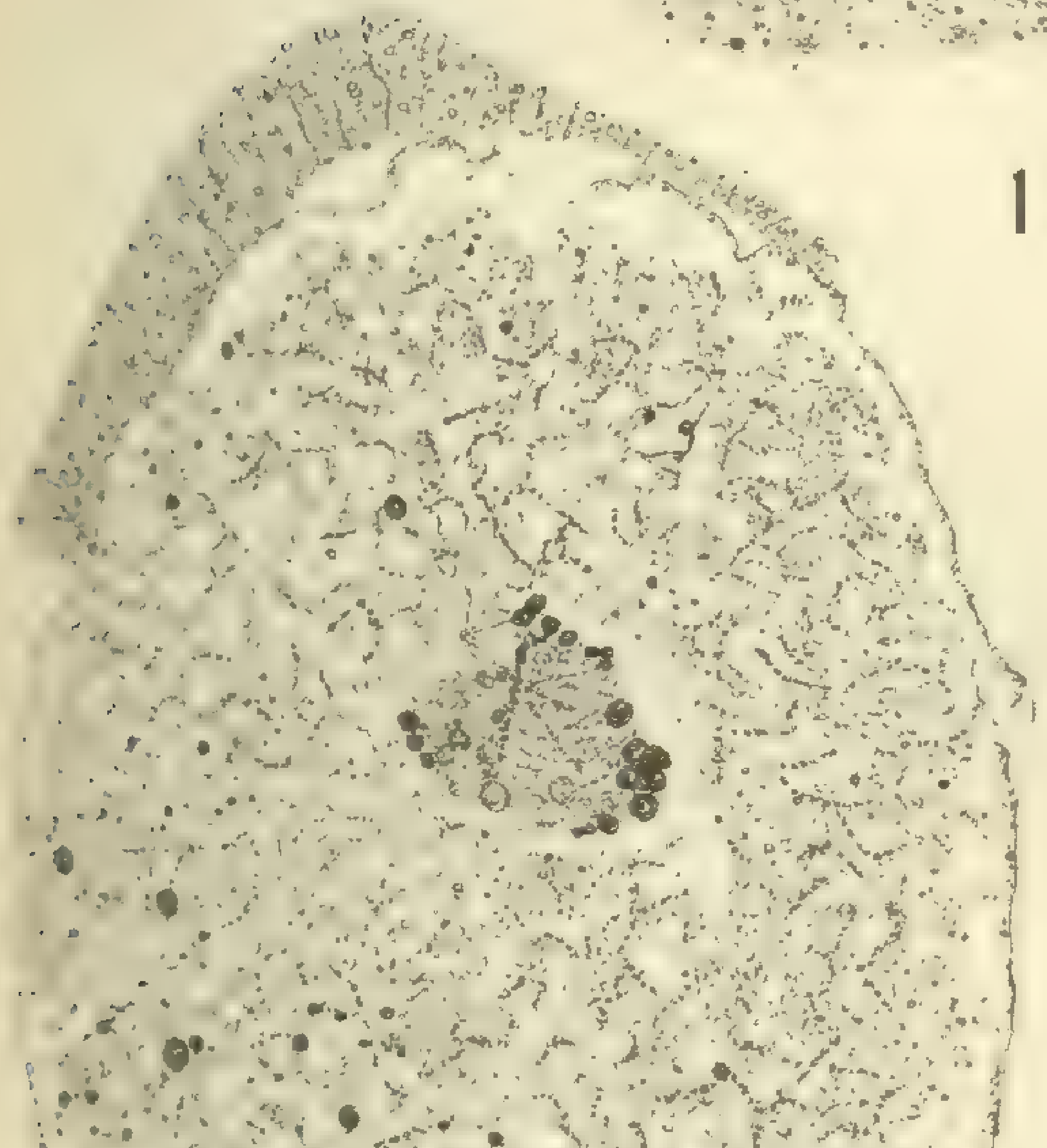

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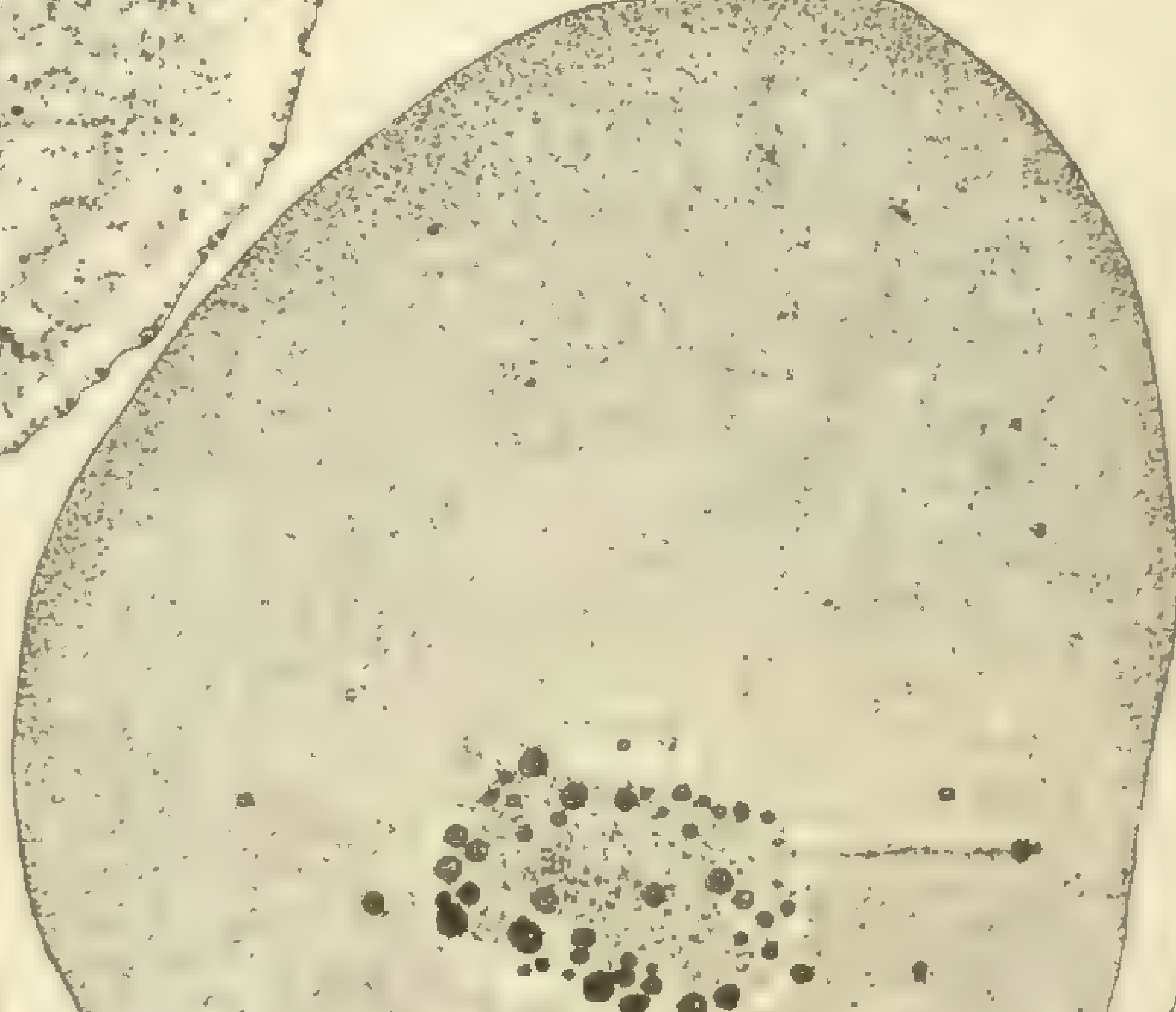

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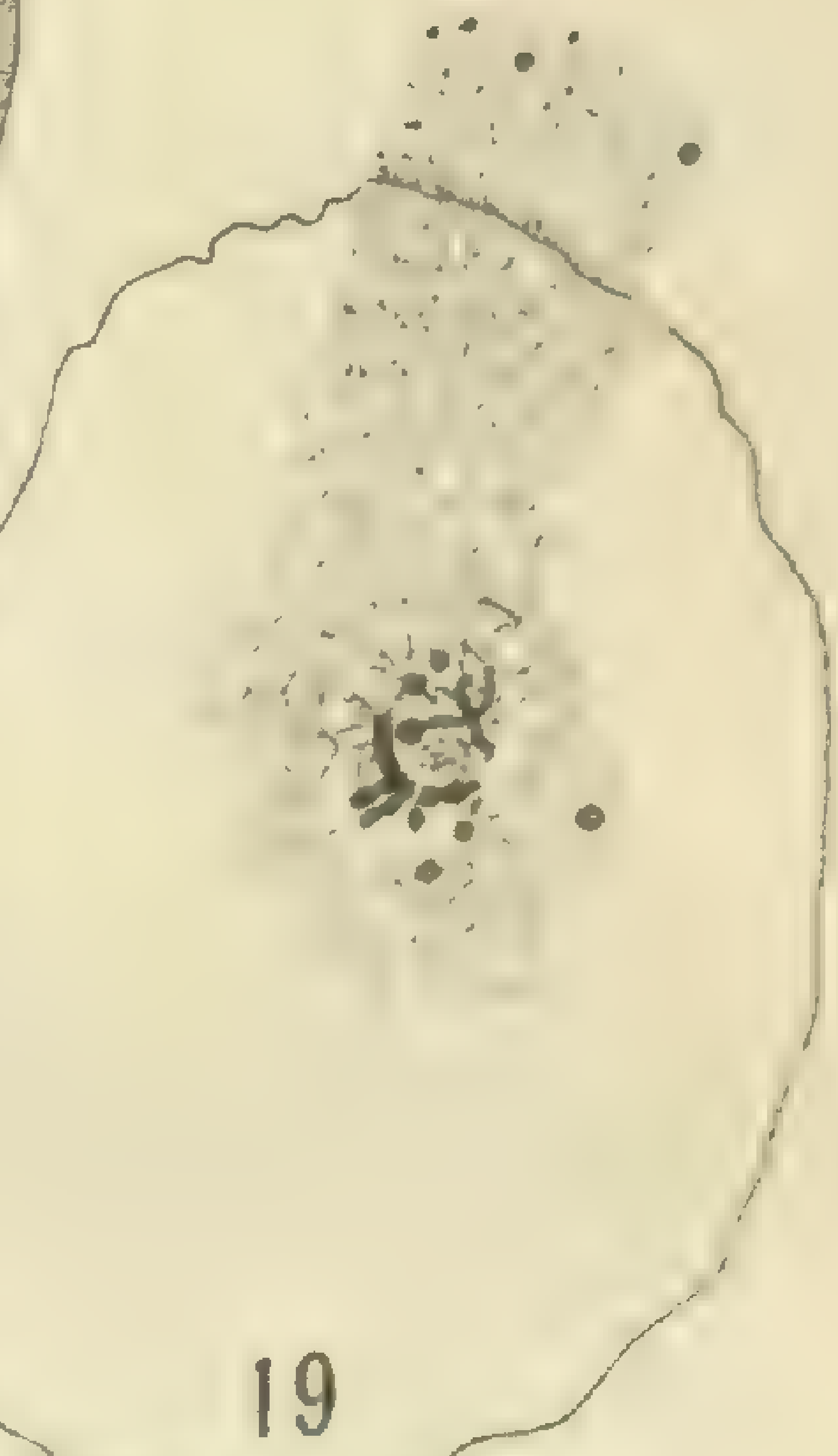

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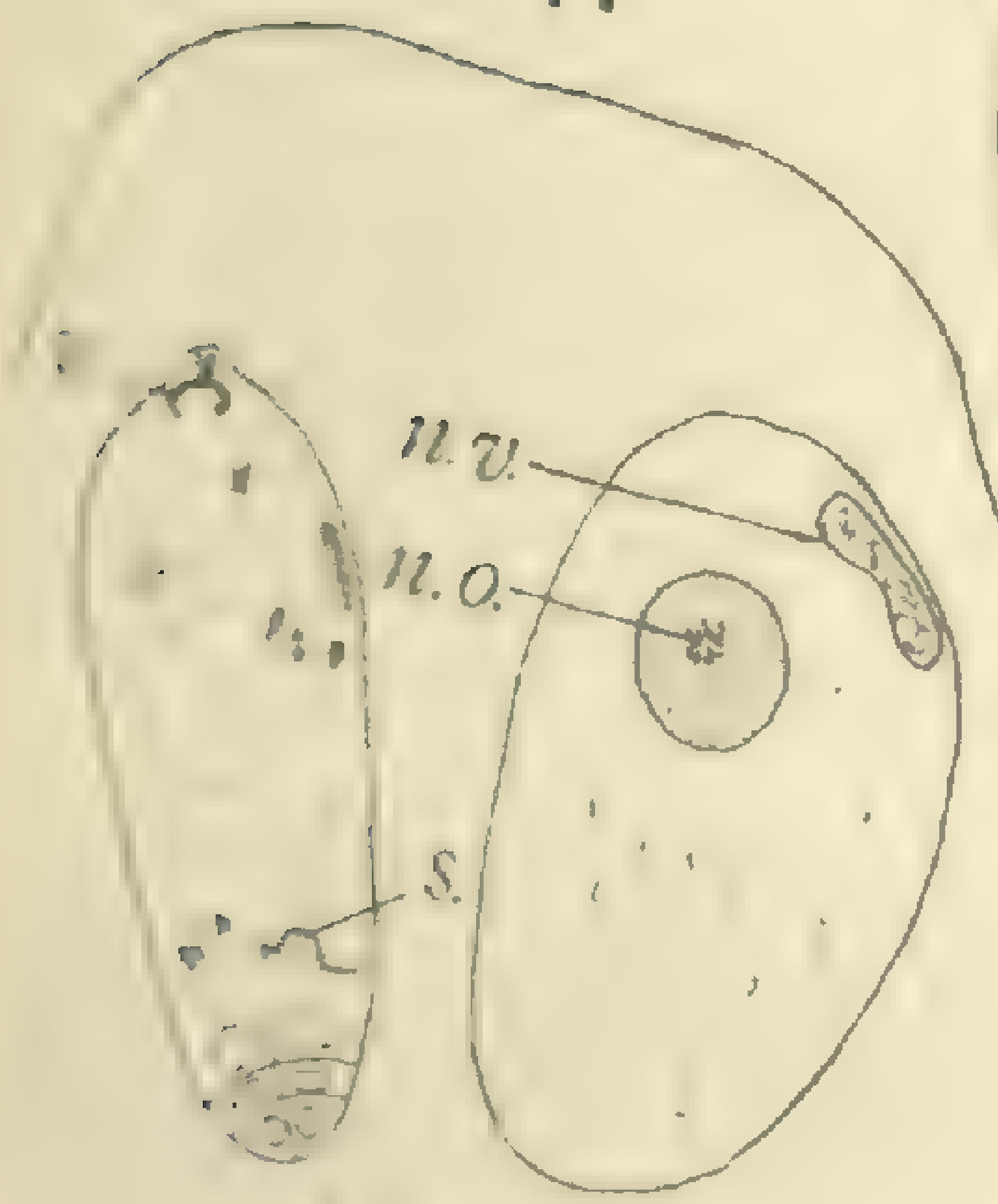

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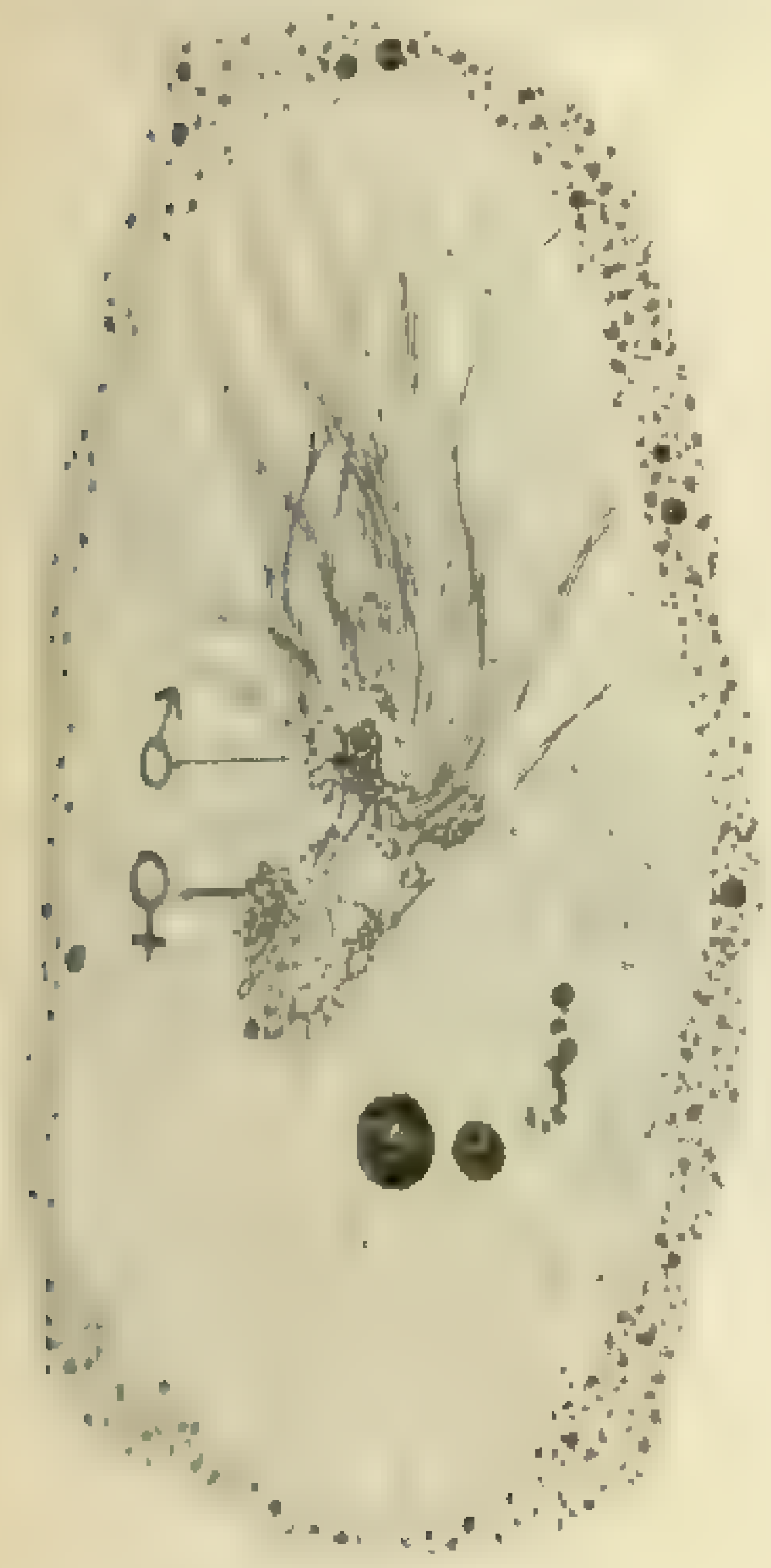
CHAMBERLAIN on OOGENESIS.



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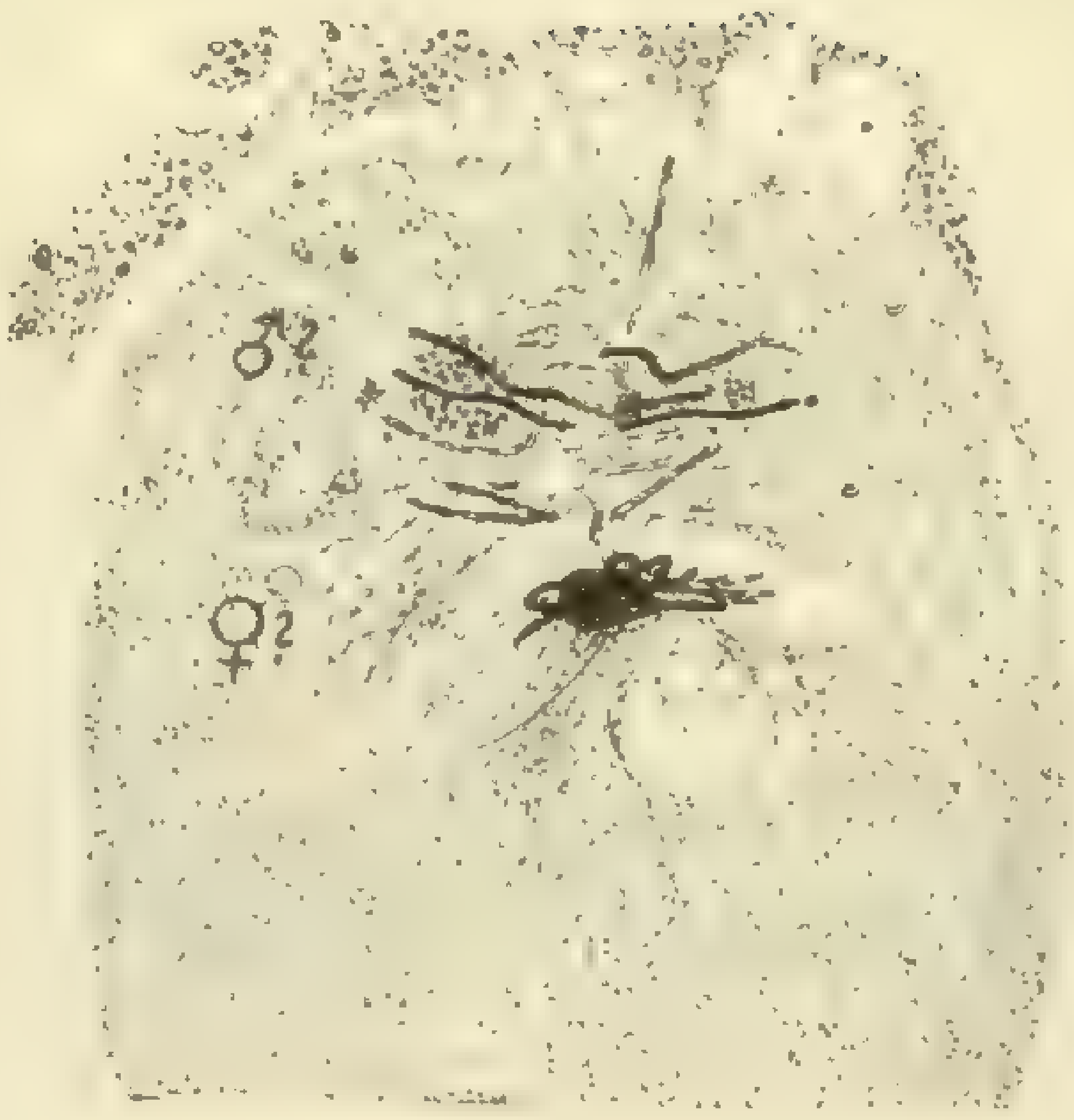

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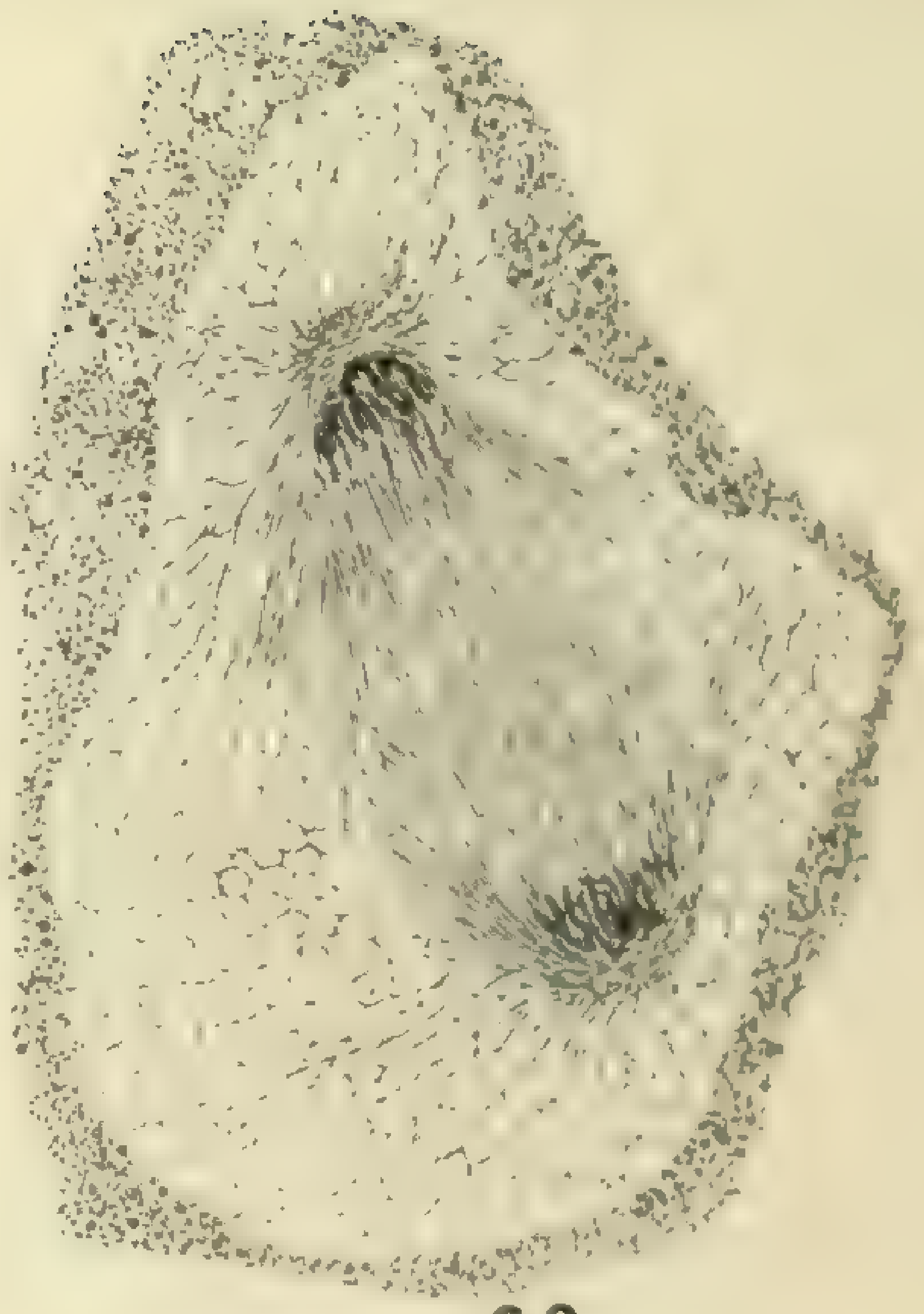

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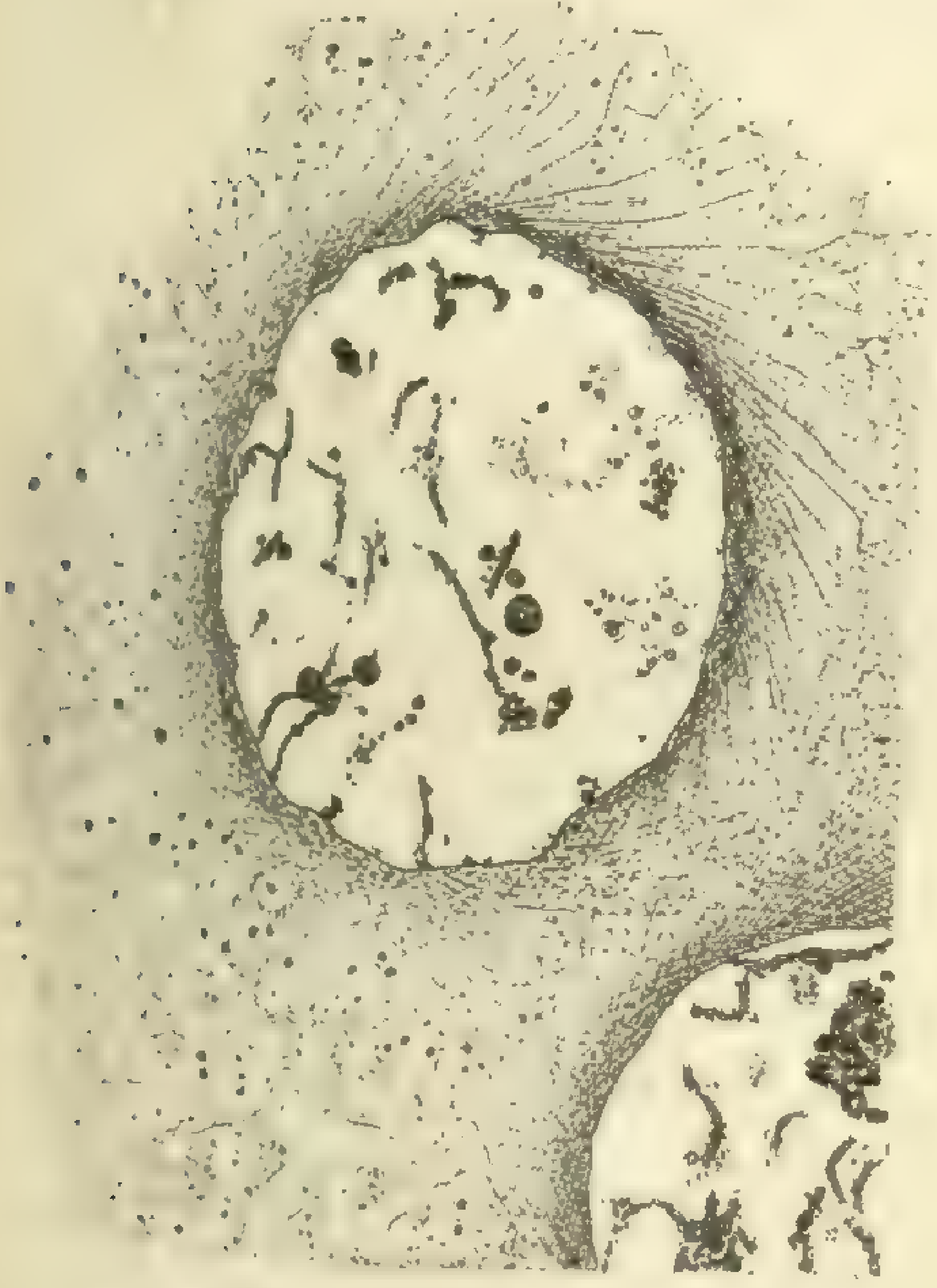

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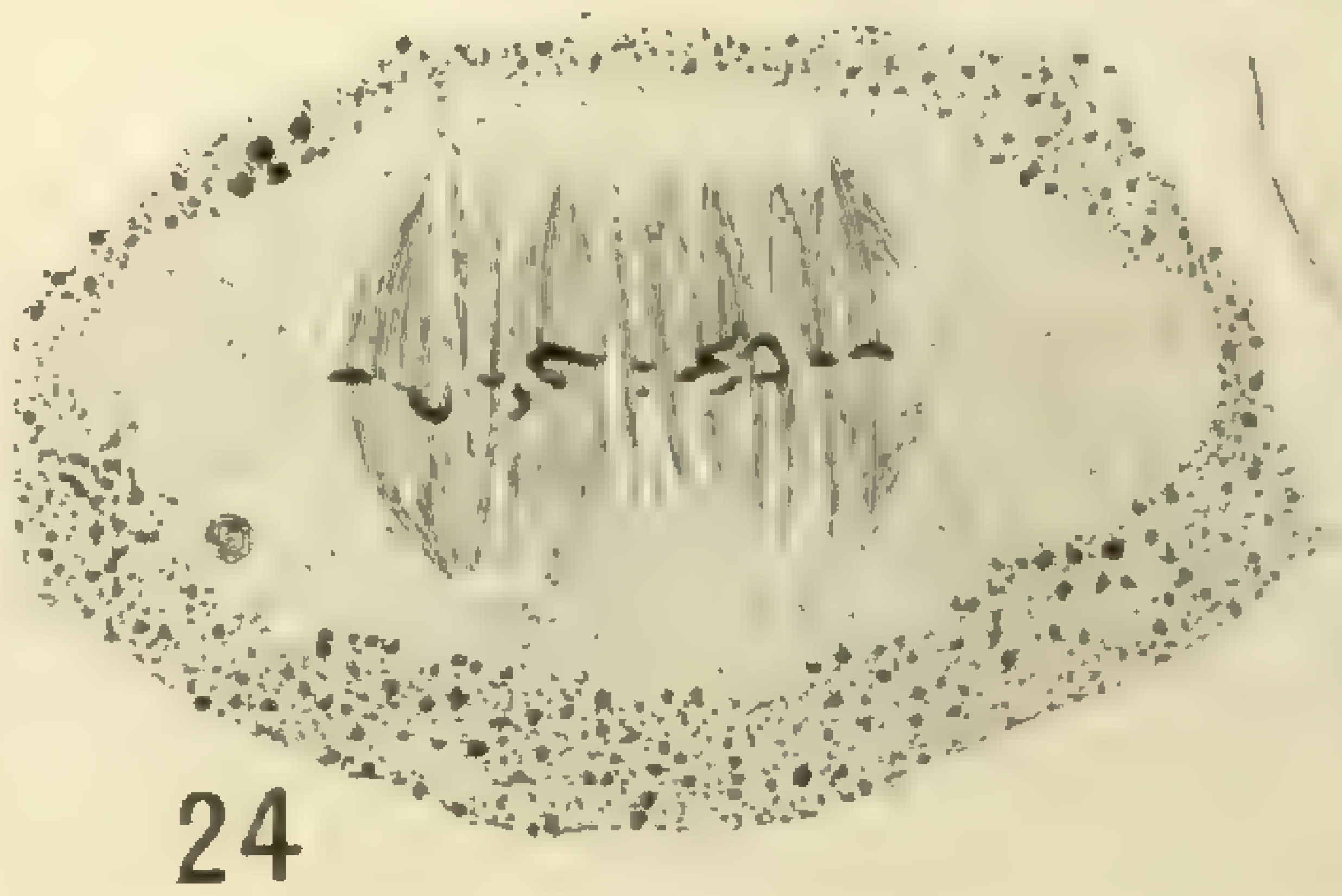

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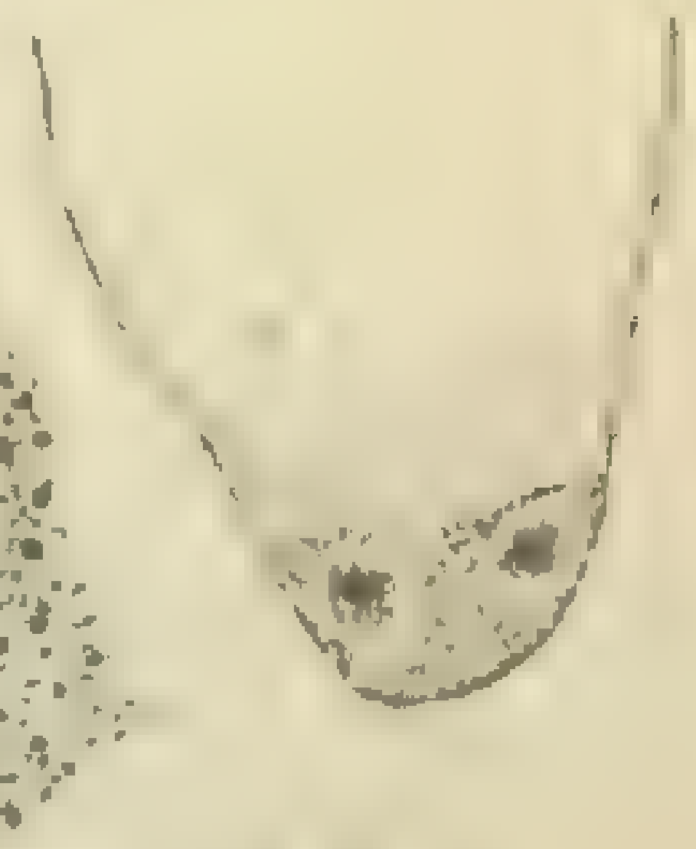

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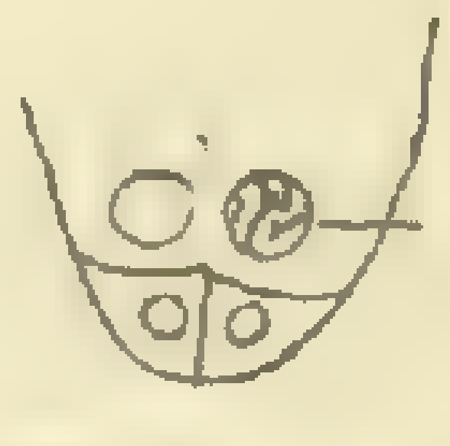

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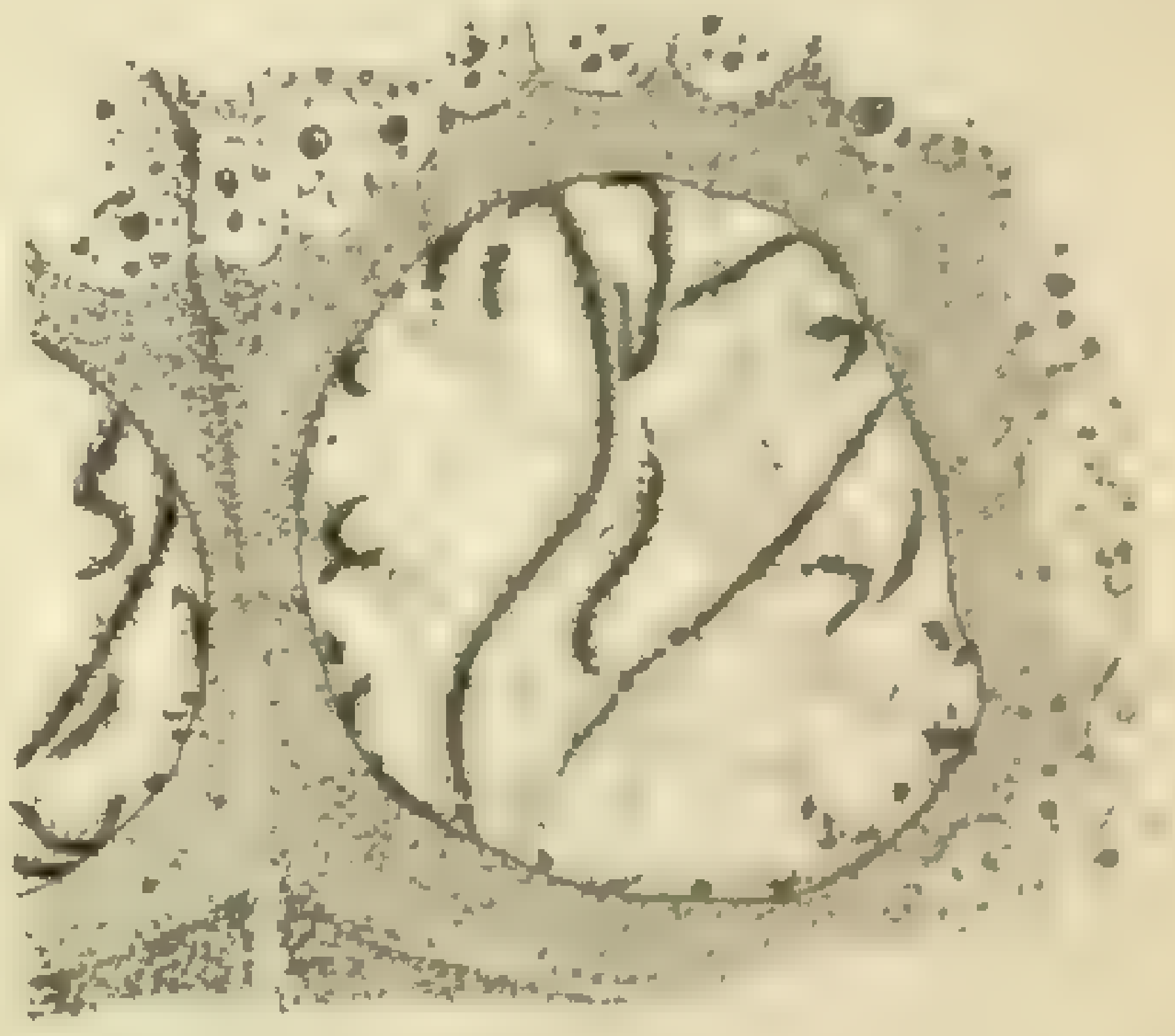

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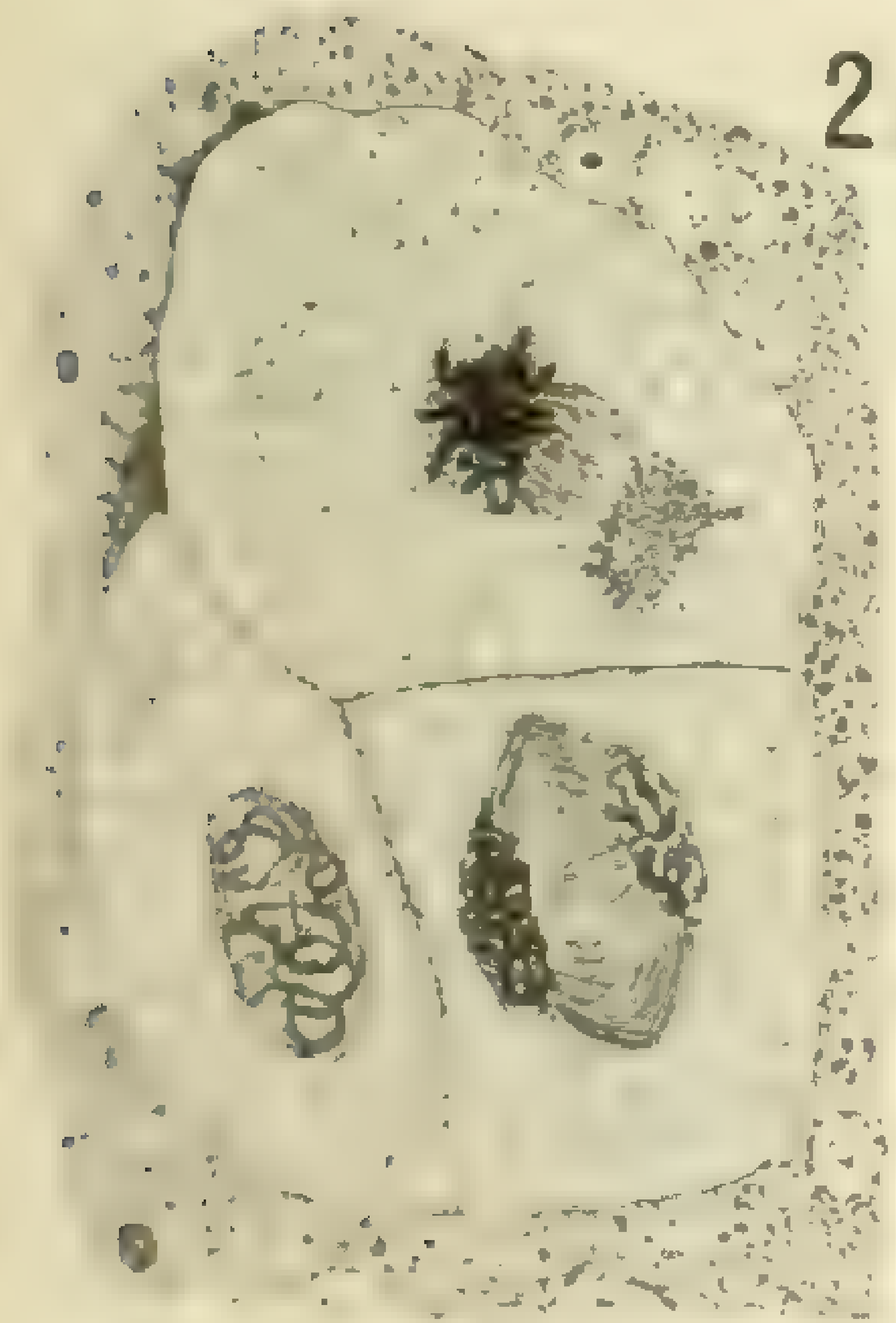

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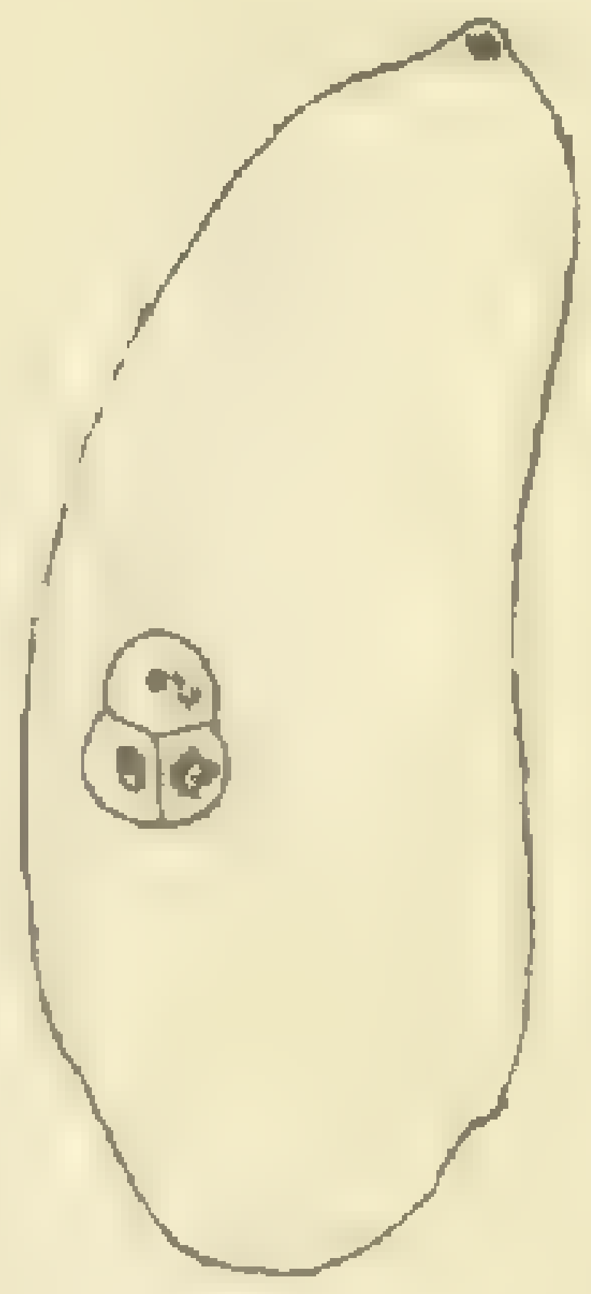

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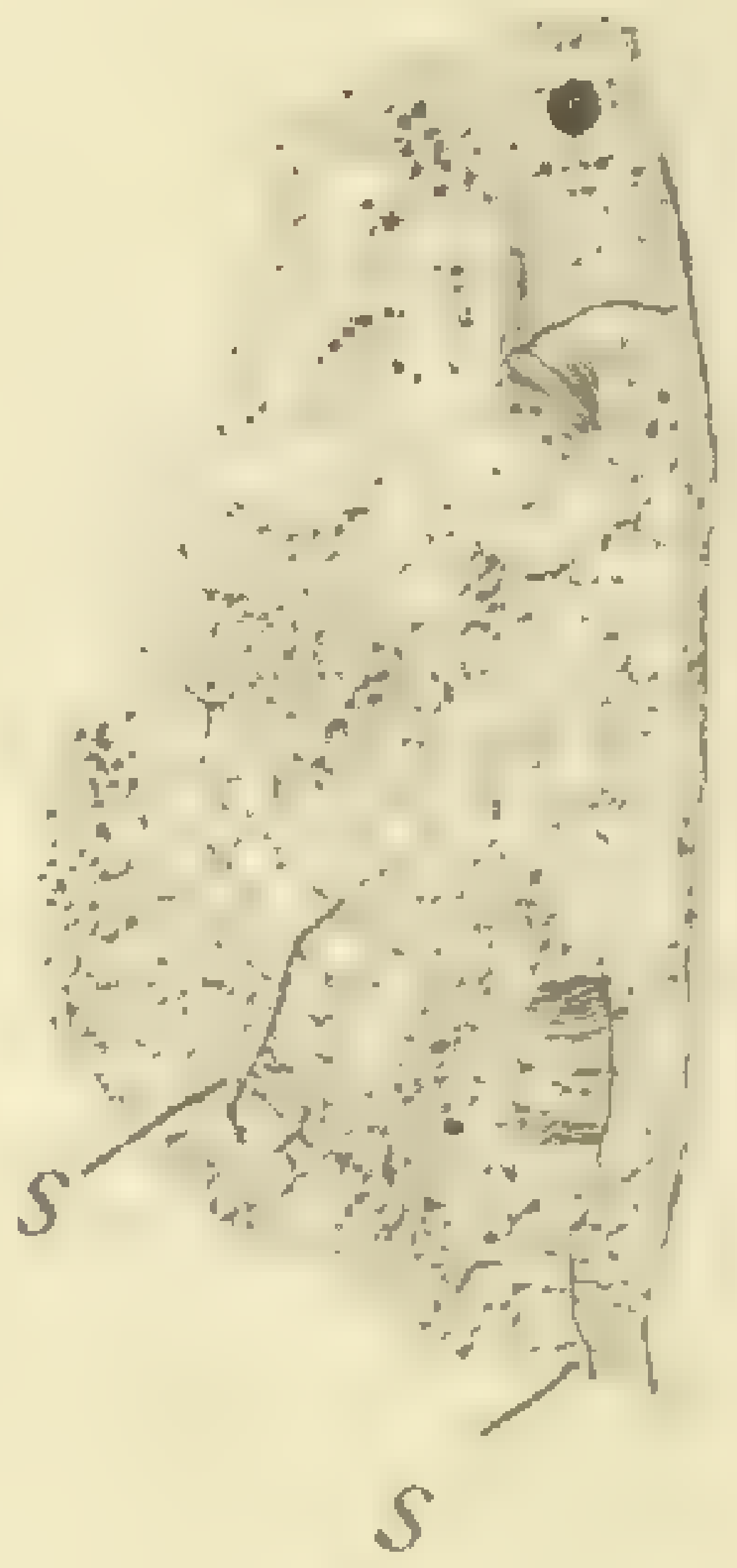

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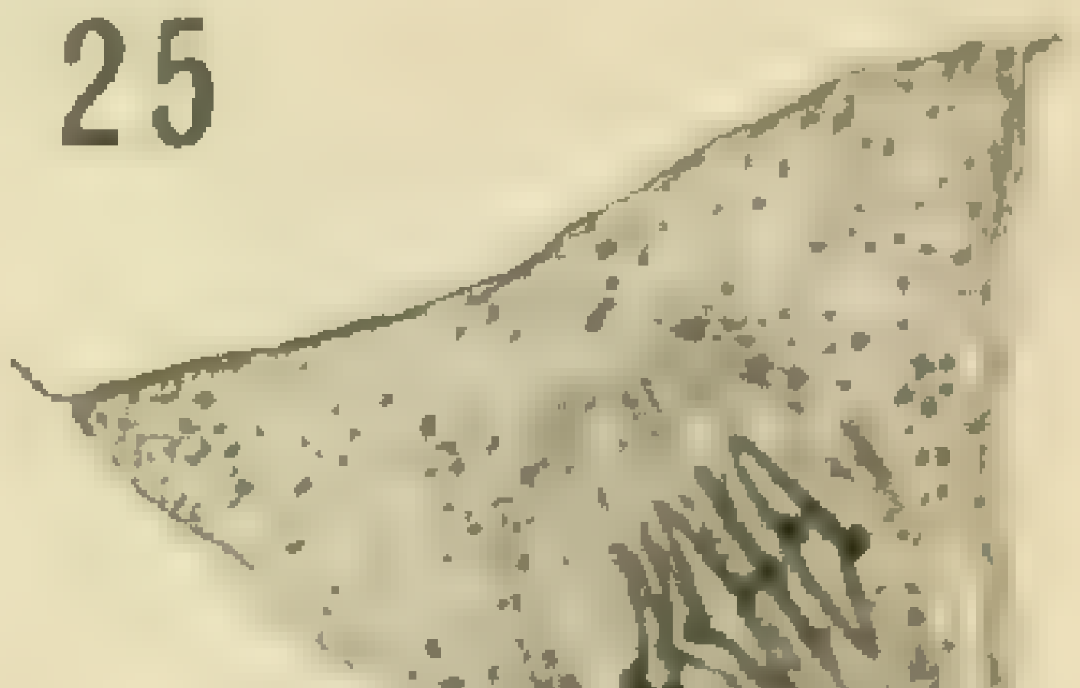

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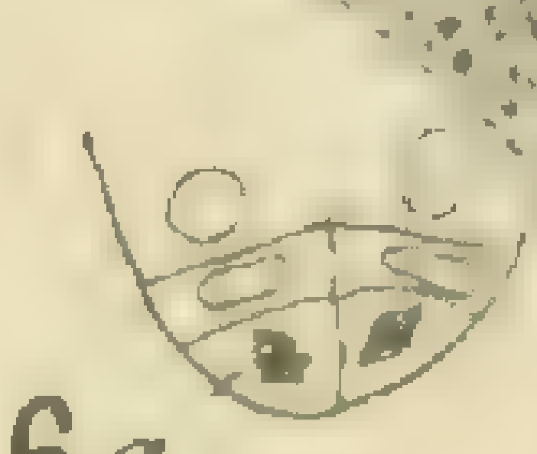

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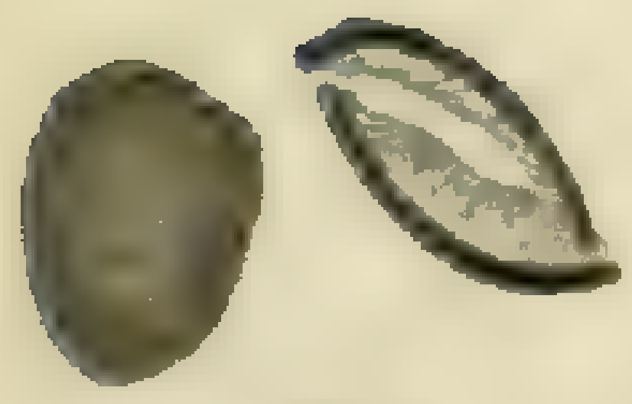

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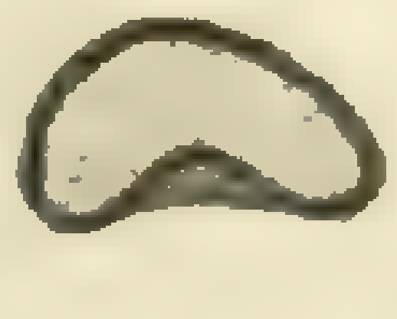

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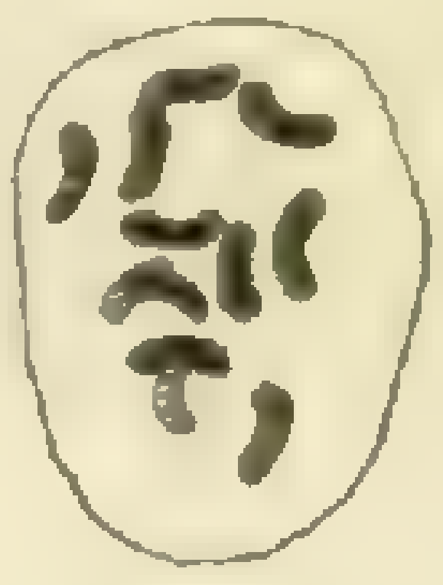

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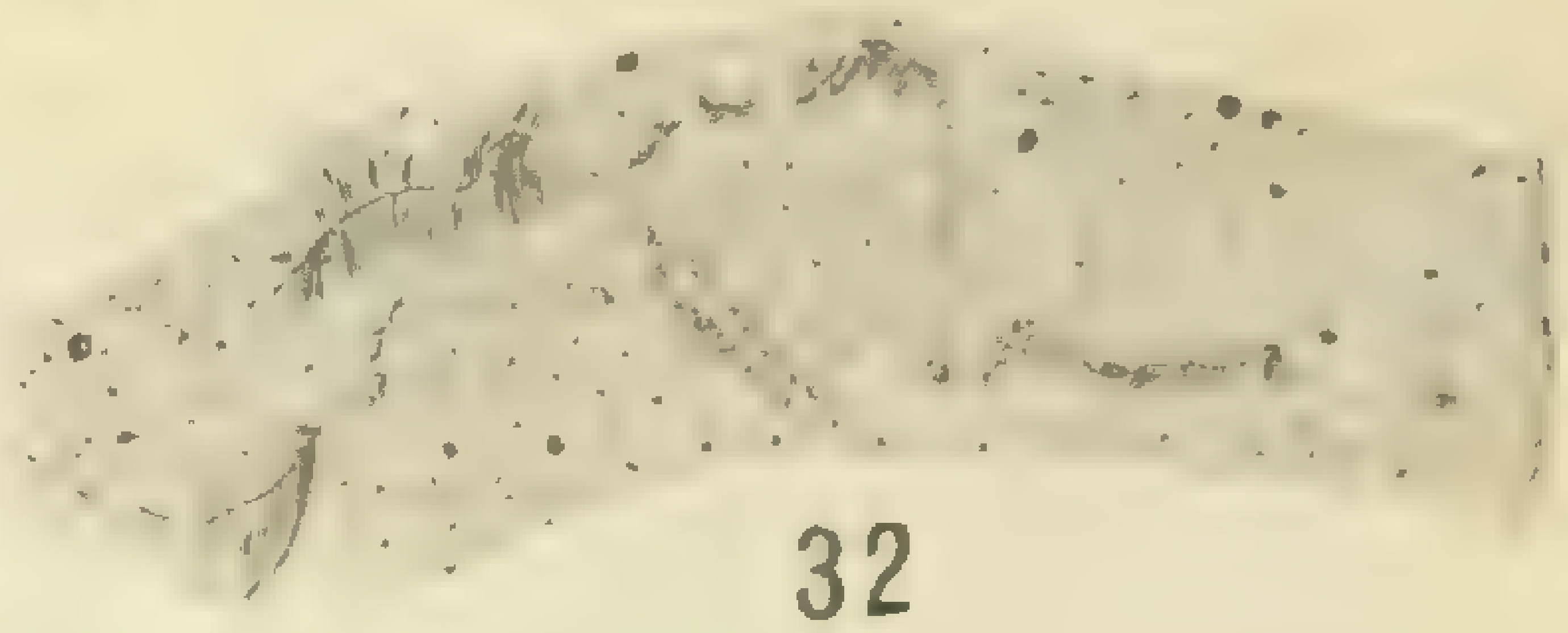

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Chas. Chamberlain del.

CHAMBERLAIN on OOGENESIS.

THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

HENRY CHANDLER COWLES.

[*Continued from p. 202.*]

3. *Encroachment on preexisting plant societies.*

THOSE who are at all familiar with wandering dunes are acquainted with their power to destroy vegetation in the path of their advance. This, indeed, is to many people the most conspicuous feature of a sand dune area, because it often becomes a feature of the greatest economic importance. The effect of an advancing dune upon the preexisting vegetation varies greatly as conditions vary. The most important factors are the rate of advance, the height of the advancing dune above the territory in its path, and the character of the vegetation that is encroached upon.

The rate of advance is, of course, a decidedly variable factor, since all rates, from nothing up to the maximum rate, may be found along nearly all advancing lee slopes. At a given point the rate varies greatly during different seasons. An advancing portion may become checked and a checked portion may advance again, as wind-sweeps are clogged up or opened once more. The multiform changes on the complex, each and all, affect the rate of advance to a remarkable degree. Attempts have been made to measure the maxima of advance at Dune Park, but a sufficient time has not elapsed as yet to allow of any satisfactory conclusions. In November 1897 a stake was driven at the basal edge of a rapidly advancing lee slope. The height of this stake above the ground was a little more than a meter. In May 1898 the stake was nearly covered, and it could not be found at all in July. At this point, therefore, the vertical component of advance amounted to a meter in six months; the horizontal component, of course, was greater still,

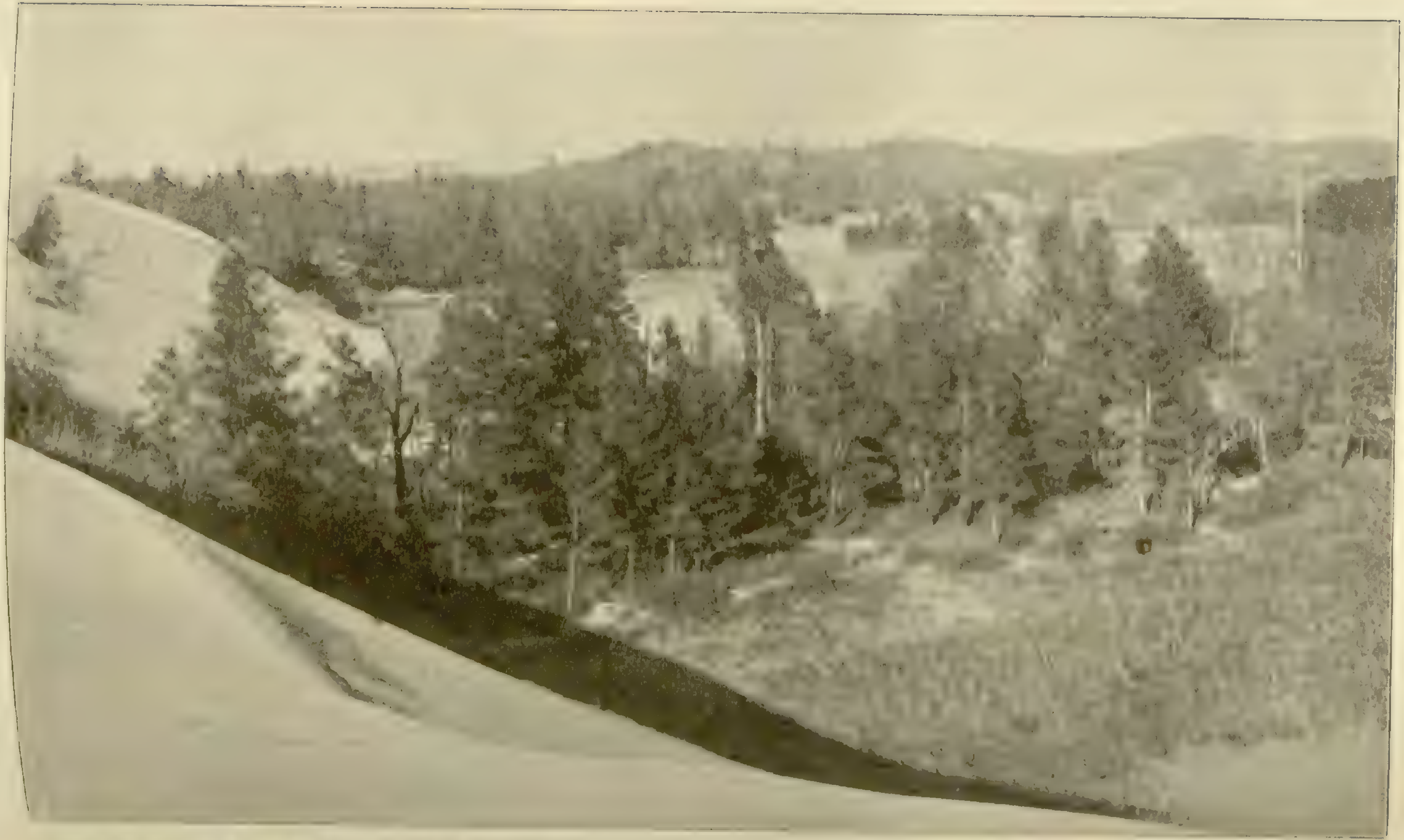

Fig. [illegible].—General view at Dune Park, showing the encroachment of a dune on pools, swamps, and forests. Dune crest in the left background, oak dunes at the right. Wind ripples in the foreground. View taken in winter.

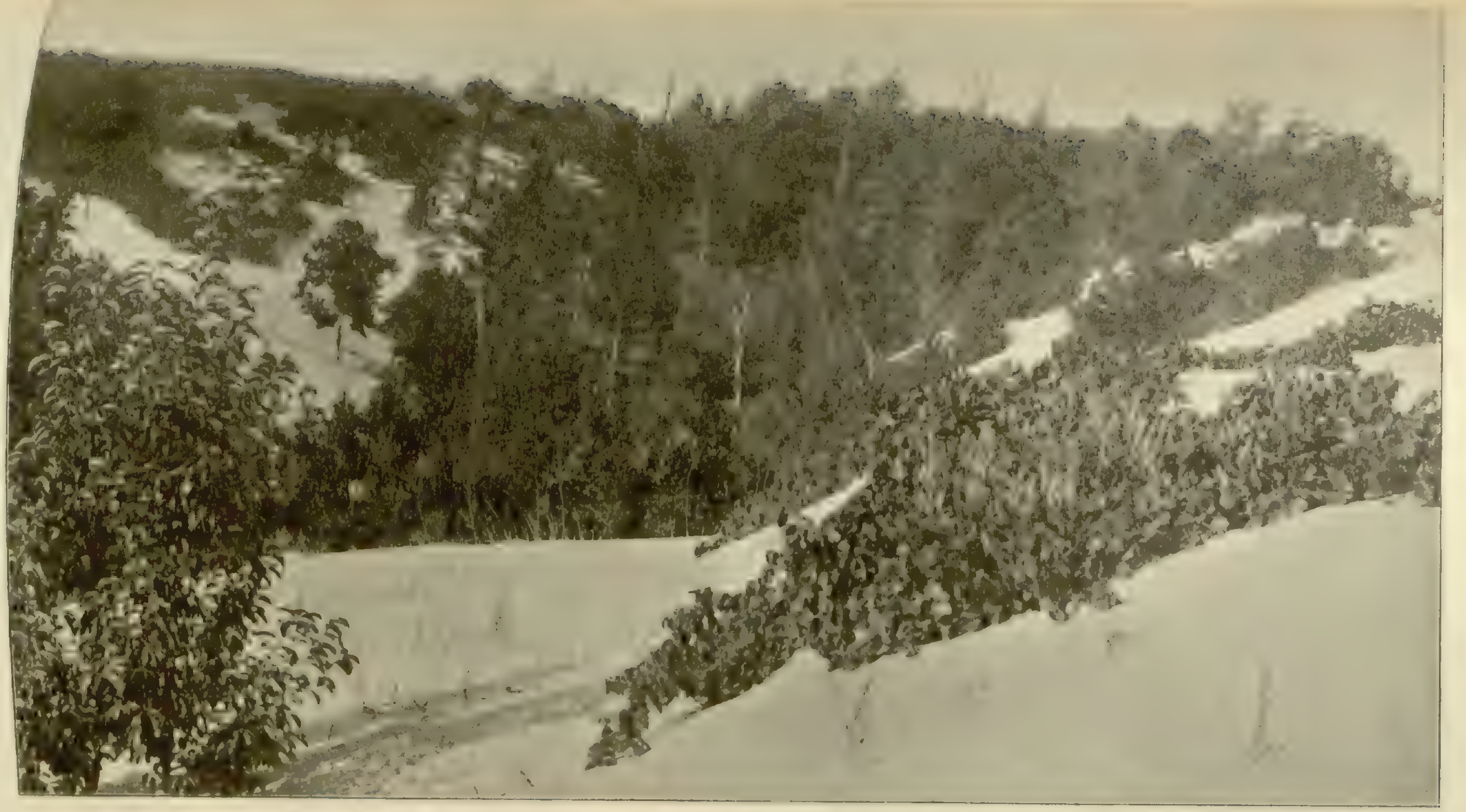

FIG. 10.—A doomed forest of basswoods, etc., at Dune Park. Dunes encroaching from all sides, but somewhat slowly; dune at right advancing in the direction of the prevailing wind. Thicket of basswood, dogwood, etc., at the left background. Subsequent vegetation in the foreground (grape at right, chokecherry at left).

since the angle of slope was about 30°. The general statement may be made for the Dune Park complex that the maxima of advance are to be measured in decimeters or meters per annum, rather than in centimeters or decameters. No estimates can be given for other localities. In all probability the Glen Haven dunes move more slowly, since the slopes have a much richer vegetation.

The height of an advancing dune above the territory in front of it is a very important factor, inasmuch as it often determines the life or death of a flora. At Glen Haven, where the advancing dunes are from thirty to sixty meters high, no preexisting vegetation can survive the burial which awaits it. At Dune Park, where the crest is never as much as thirty meters high, vegetation sometimes survives. This survival is determined chiefly by the nature of the vegetation, and the succeeding paragraphs will have to do with the struggle between dunes and floras at Dune Park.

The advancing dunes at Dune Park encroach now upon a swamp, now upon a forest. *Fig. 9* shows how these forest and swamp conditions alternate. In the right foreground is a pool, surrounded by bulrushes. Toward the center of the photograph there is a ridge tenanted by pines and oaks, then another swamp and another ridge. *Fig. 10* shows a very interesting phenomenon. At the center is a deep trough, surrounded on all sides by advancing dunes. This trough has never been a wind-sweep, but was made by the piling of the sand all about it. The flora in this depression is not a typical sand-dune flora, although surrounded by such on all sides. It is a mesophytic island in a xerophytic sea. The dominant trees in this little group are the basswood, *Tilia Americana*, and the ash, *Fraxinus Americana*. Although the basswood is common on the arrested dunes, this plant society is quite evidently a relict of a larger area developed under more genial conditions. The lake is toward the right, and the dune on that side is advancing with some degree of rapidity. The dune to the left is pushed forward in the main by the action of southerly winds, and moves quite slowly. This dune, however, is at the upper end of the curved wind-sweep previously mentioned, so that northwest winds contribute to its advance. Thus it becomes possible for the same wind to cause the advance of two dunes toward each other and hasten the burial of a flora. The advance of all dunes at this point is relatively slow, as is shown by the comparatively abundant vegetation on the advancing slopes. This vegetation is not a relict of the past. The advancing dunes completely destroy all of the preexisting vegetation at this point. In a few more years, unless conditions change, there will be nothing left at the surface by which one may interpret the history of this dying plant society.

The encroachment of a dune upon a forest is shown in *figs. 11* and *12*. The forests in this vicinity consist principally of the scrub pine, *Pinus Banksiana*, and the black oak, *Quercus coccinea tinctoria*. Neither of these trees can survive any such degree of burial, as can the cottonwood. The oak, especially, succumbs long before the entire tree is buried; the dead trees along the dune margin in both pictures are oaks. *Fig. 12* shows a pine that is half buried, but apparently as vigorous as ever. The dead trees in *figs. 15* and *16* are mostly scrub pines, and they seem to show no greater adaptation to their new surroundings than do the oaks. There appears to be a wide range of individual adaptation in pine trees, some dying almost as soon as the dune reaches them at all, while others are nearly as resistant as the cottonwood. In both pines and oaks the first obvious sign that the tree is waging a losing struggle is etiolation. The dying trees along the margin (as in *figs. 11* and *12*) rarely have a dark green foliage. In most cases the leaves are yellowish green, and in some cases almost white. Nor are the leaves as numerous or large as on healthy trees.

Such tree groups, as are shown in *figs. 9*, *10*, *13*, and *14*, are doomed to an inevitable death. The length of life allotted to them in the future depends almost entirely upon the rate of the dune's advance. There are some evidences in favor of the view that an individual pine tree can endure a deeper covering before

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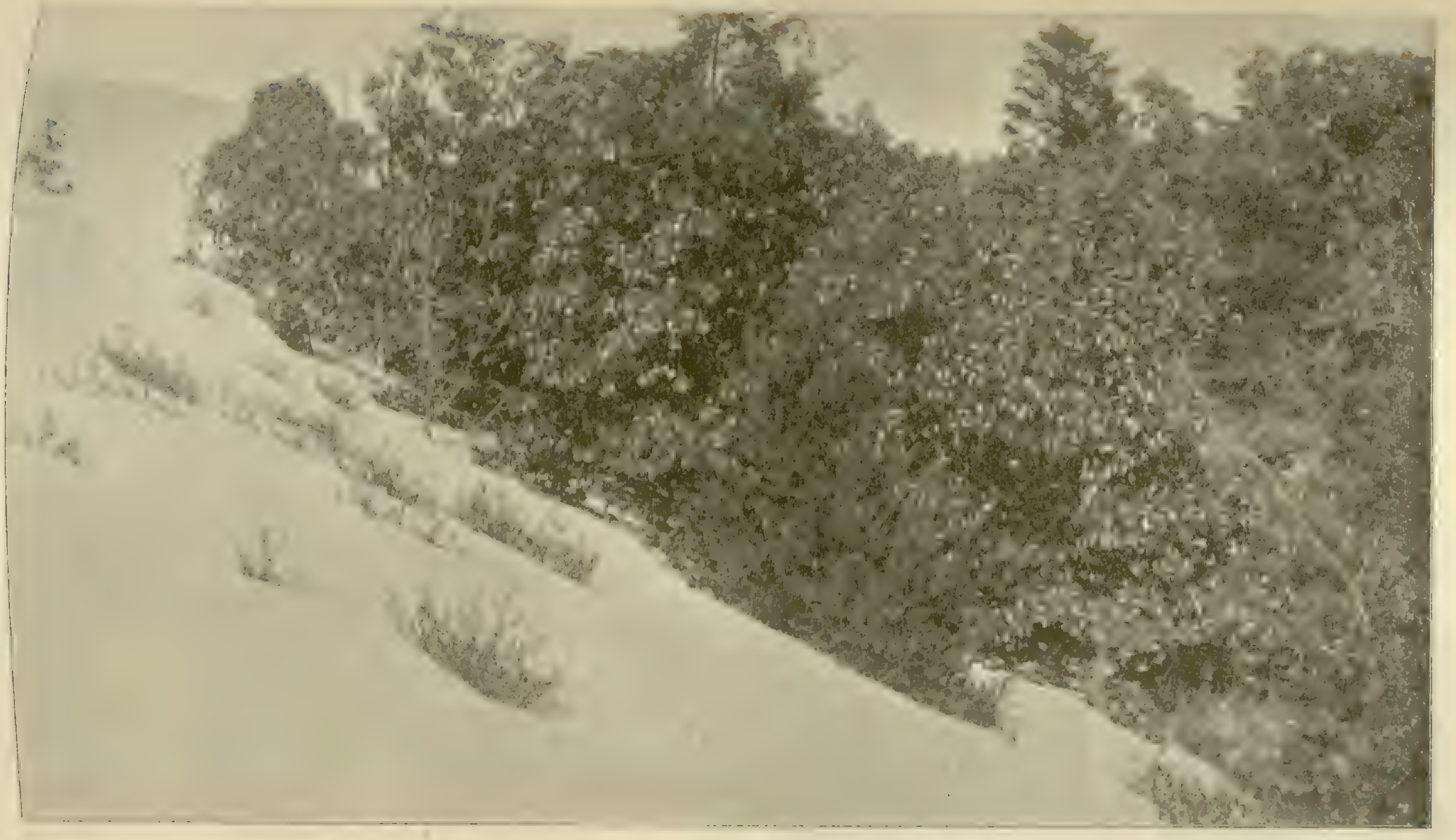

FIG. 12.—Encroachment of a dune upon an oak forest at Dune Park. Bugseed in the left foreground. Half buried but vigorous pine at the center. Dead oak trees at the margin.

death ensues, if the rate of advance is slow. *Fig. 12*, which represents a half buried pine that is still vigorous, was taken at a point where the advance is relatively slow. *Figs. 15* and *16*, on the other hand, where the pines were soon killed, represents one of the most rapidly advancing dunes at Dune Park. Thus the individual adaptation referred to in the preceding paragraph may be in part delusive. Perhaps the trees are able to adapt themselves more fully, and hence undergo a greater degree of covering before they die, where the advance of a dune is comparatively slow. Sometimes (as in *fig. 11*) the territory toward which the dune advances is higher than the dune itself. In such a case the advancing dune is checked. If the entire area in front is higher than the dune, the sand gradually accumulates until the altitude is great enough to permit another advance. When, however, a ridge meets the advancing dune at right angles (as in *fig. 9*), the dune's course is deflected to either side. If the ridge is high enough, some of the trees may be able to escape the fate of their associates. The pines in the background of *fig. 17* probably represent a portion of the flora at the top of one of these ridges.

At Glen Haven, as has been stated, the forest vegetation readily succumbs, because of the great height of the advancing dune. The forests are mainly of two types, the maple or the arbor vitae. The maple forests have a dominance of *Acer saccharinum*, and represent the most common type of mesophytic forest in that part of Michigan. The arbor vitae forests are in reality swamp forests, and the most typical trees present there are *Thuya occidentalis*, *Betula papyrifera*, and *Fraxinus Americana*. The line of dead trees along the margin of the advancing dune (as shown to a slight extent in *figs. 11* and *12*) is particularly striking where there is an encroachment upon a maple forest. Sometimes the hemlock, *Tsuga Canadensis*, grows with the maple and shares its fate. At one point the dune encroaches upon a forest of *Pinus Banksiana*, and the results are precisely as at Dune Park.

Dunes that are encroaching upon forests may be found along the entire coast, though their best development is in association with an extensive dune-complex, as at Dune Park or Glen Haven. The burial of forests was observed at Frankfort, Muskegon, and elsewhere, and is a relatively common phenomenon. In closing up the treatment of the forests, the general statement may be made that an advancing dune destroys the entire forest vegetation. Where this rule meets with any exception, it is an exception that in no real sense invalidates the main proposition.

The encroachment of a dune upon a swamp is of less common occurrence than encroachment upon forests, because forests are so much more common than swamps along the lake shore. The best examples of dunes advancing on swamps were seen at Dune Park, where there are a number of swamps that run more or less parallel with the lake shore. *Fig. 9* gives a good impression of the general appearance of things in the vicinity of Dune Park. In the foreground is a pool and bulrush swamp upon which the dune is encroaching. Beyond the wooded ridge at the center is another swamp of the same type, which is suffering the same fate. In the distance there can be seen the crest of a dune, which is advancing upon a chain of forest-clad hills.

The dune which is shown in the foreground of *fig. 9* encroaches upon a pool in which there is an abundance of aquatic plants, such as *Nymphaea odorata*, *Nuphar advena*, and *Pontederia cordata*. These plants are soon destroyed, of course, but it is surprising how long it is before they die. Leaves of Nymphaea and Nuphar have often been seen raised above the sand, a meter back of the present margin of the pond. These plants must have been partially buried for some weeks, and yet the leaves were scarcely blanched at all. Indeed, an oak tree buried to an equal relative depth would have succumbed entirely. Around the margin of the pool is a luxuriant growth of the bulrush, *Scirpus lacustris*. This plant soon gives up the struggle, etiolation being present when only the basal portion of a stem is buried. The appearance of the bulrush is often striking by reason of the fact that there are etiolated rings alternating with green rings of stem tissue.

[illegible] swamp has stopped a rapidly advancing dune at Dune Park. [illegible] swamp and pine bottom, [illegible]

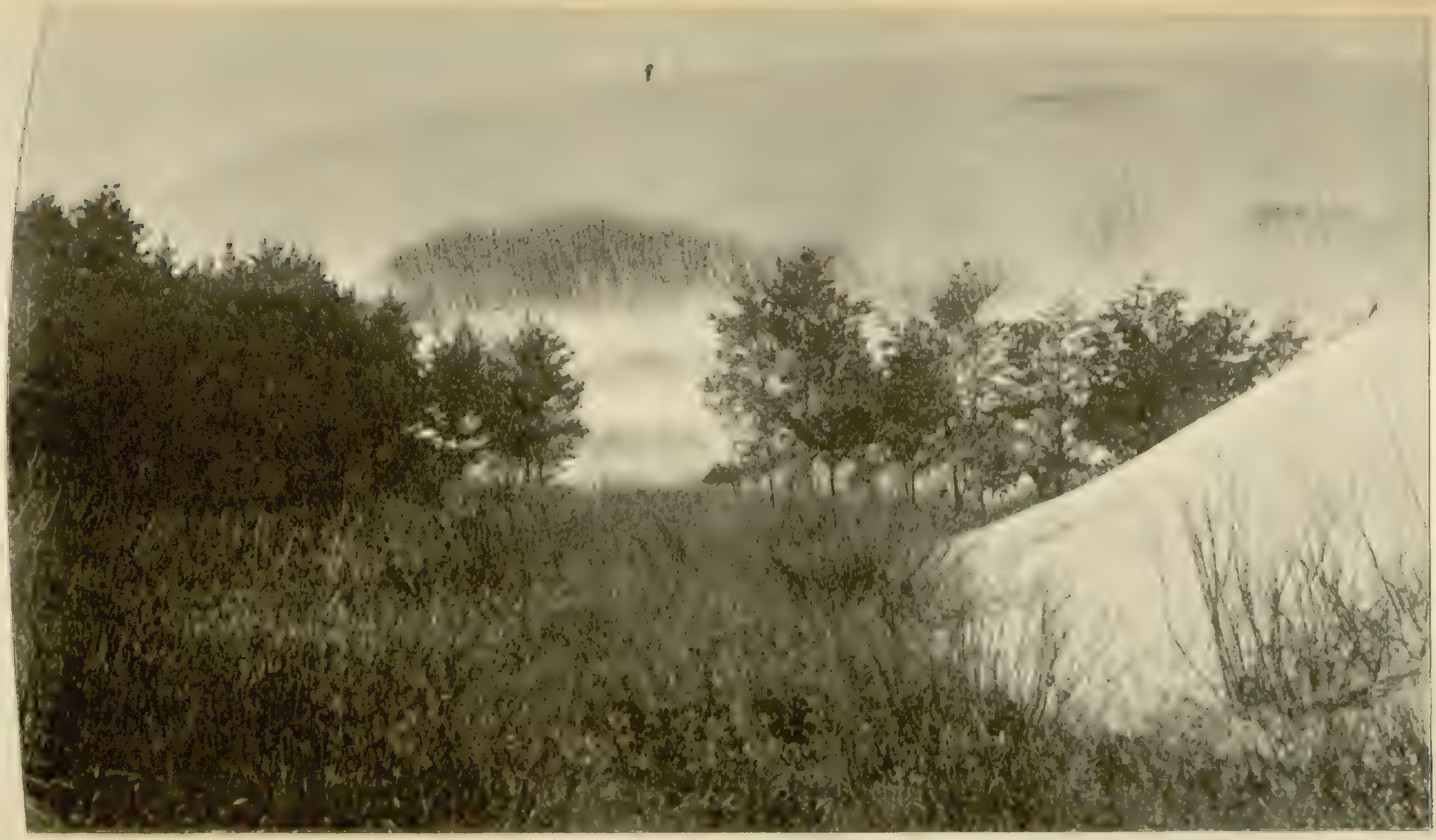

FIG. 14.—Steep lee slope of a rapidly advancing dune at Dune Park. Encroachment on a swamp and pine bottom. Pocket in the dune with pines. Dogwoods on the slopes. View taken in winter.

Fig. 13 shows the encroachment of a low dune upon a sedge swamp. The beachlike fringe of sand at the base of the dune is peculiar to dunes that encroach on swamps. Considerable sand rolls or is blown beyond the base of the steep slope. Under ordinary conditions this sand is blown away, but as soon as it reaches the wet, swampy ground, it becomes moist, and hence remains for a time as a fringe to the dune. The plants of a sedge swamp are unable to adapt themselves to a dune environment, and quickly succumb. *Fig. 14* shows a dune advancing on a more mesophytic flora and on a group of pines. The effect here is also destructive, in the main. An interesting pocket in the dune, in which there is a group of pine trees, appears in this figure.

One of the most remarkable phenomena seen in the dune region is shown in *fig. 15*. A dune about twenty five meters in height is advancing with considerable rapidity upon a bulrush swamp. This swamp is more or less continuously surrounded by a marginal fringe of willows and dogwoods. The bulrushes are quickly destroyed, but the dogwoods and willows have thus far been able to remain not only alive but luxuriant. In order to keep above the sand, these plants are obliged to lengthen their stems far more than is ever the case under normal conditions. Already some of these plants have twice and three times their normal stem height. The buried portions of the stems, particularly of the willows, send out roots almost as soon as they are buried. These plants, therefore, become more and more independent of the deeper soil in which they first grew, thus escaping one of the greatest dangers that was mentioned in connection with many tenants of the embryonic dunes.

Three species have been found that are able to adapt themselves almost immediately to a dune environment, *Salix glaucophylla*, *S. adenophylla*, and *Cornus stolonifera*.[3] The taller shrubs in *fig. 15*, as at the left of the center, are *Salix adenophylla*. The lower shrubs are dogwoods or glaucous willows. *Fig. 16* shows a group of the latter two species growing together. How long these plants will be able to endure is a question that cannot now be answered. The conditions become severer each year, because of the necessity for increased stem elongation, and also because the plants are constantly rising above the protected position in the lee of the dune. At no place is the destructive action of the wind greater than at the summit of an advancing lee slope.

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[3] Some of the *Cornus stolonifera* may prove to be *C. Baileyi*. These two species certainly intergrade in the dune region. The pubescence character is largely a question of habitat. The best determinative character is the stone, and, judged by this, nearly all specimens examined, whether from the swamps or from the dunes, were *C. stolonifera*. See BOT. GAZ. 15: 38, 86–88. 1890.

The encroachment of a dune upon an open swamp or a body of water is seen occasionally along the Michigan shore, as at Grand Haven. In no case, however, were any facts obtained that added anything essential to those given above. In concluding the section on dune encroachment, it may be said that the only conspicuous case of the survival of members of a preexisting flora is furnished by the swamps. It may at first seem a surprising fact that the plants which are able to adapt themselves to the intensely severe conditions of an advancing dune are hydrophytic willows and dogwoods, rather than mesophytic oaks, basswoods, and maples, or xerophytic pines. Such a view as this comes from a misconception of the change that is needed in the life-habits of the plant. The relation to the soil water is not conspicuously altered, or at least not rapidly altered. It is true that the elongating stem makes it more and more difficult for the plant to draw water from the original root system; but in the case of the willow, at any rate, this is counterbalanced by the development of new roots along the buried stem, which allow the plant to utilize the moisture in the sand. The trees mentioned above are unable to send out such roots, and here, at least, is one possible source of their failure.

There is another line along which the solution of this problem of adaptation may be sought. A number of ecologists in later years have commented on the xerophytic structures of many swamp plants. These structures are not to be found in all swamp plants, but are particularly well-marked in plants of

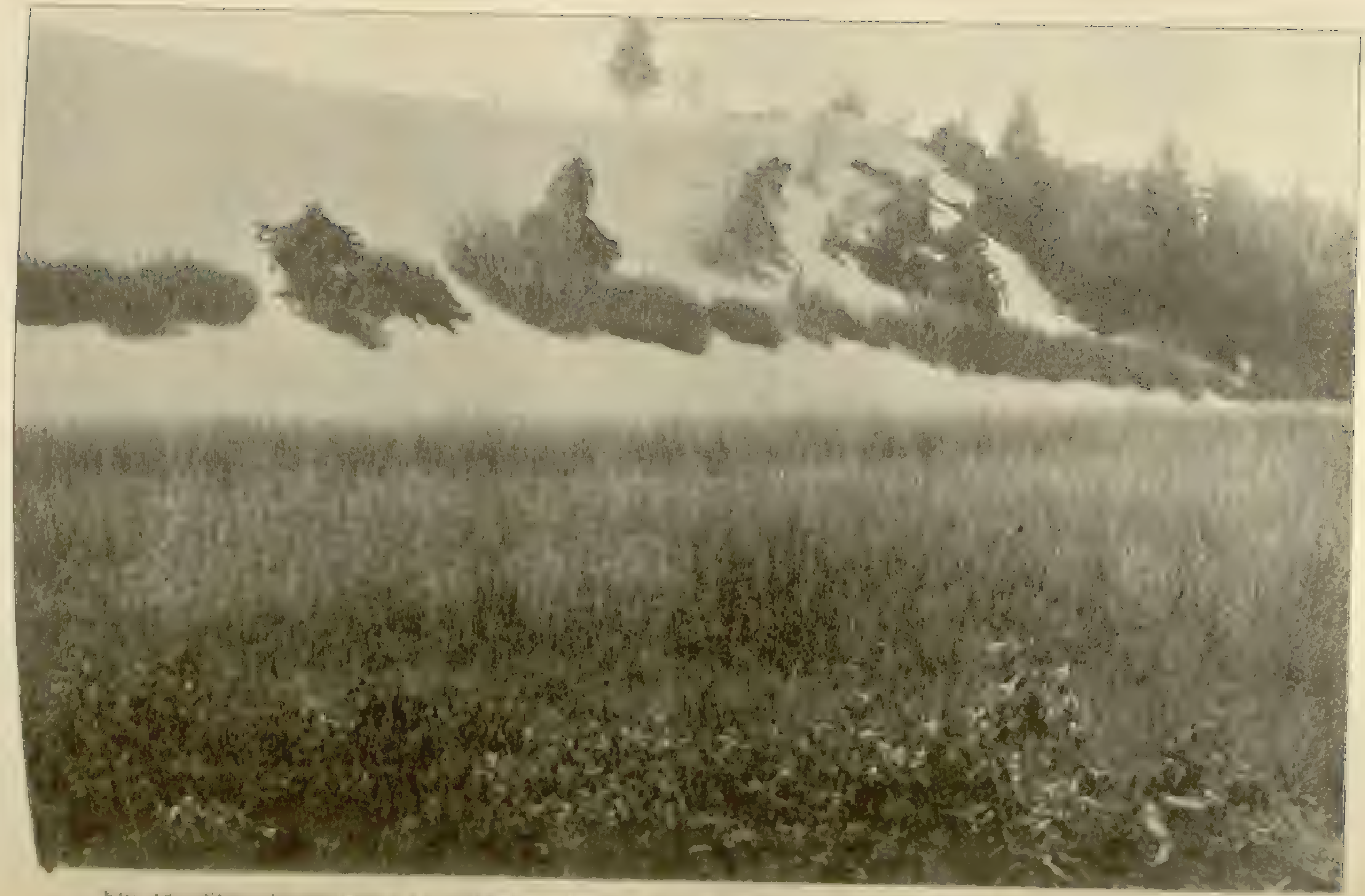

FIG. 15.—Steep lee [illegible] of a [illegible] dune at Dune Park. [illegible] a bulrush swamp, which [illegible] marginal row of willows and dogwoods. [illegible] and pines, but survival of the shrubs through vertical elongation enabling them [illegible]

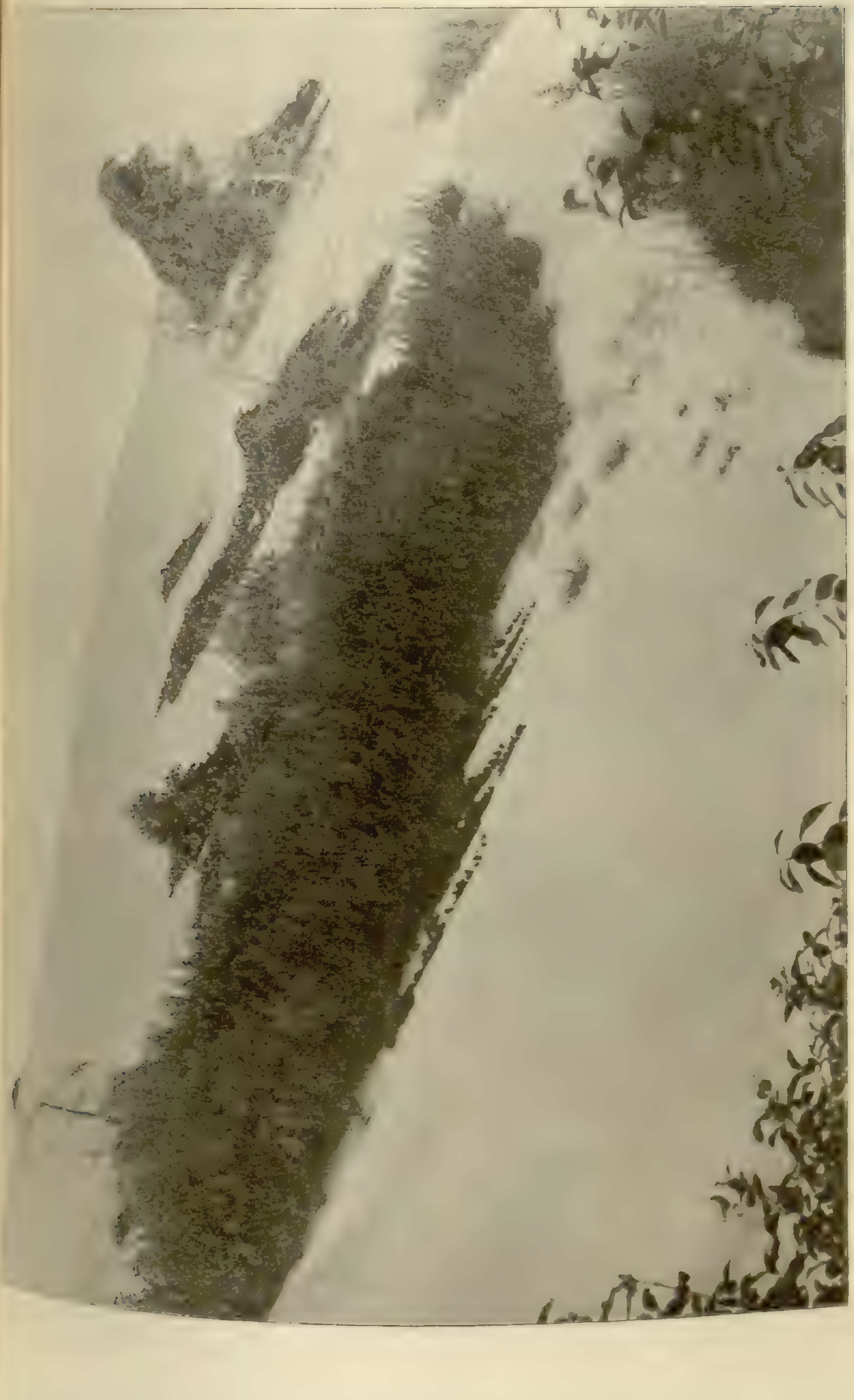

FIG. 16. Section of the lee slope shown in *fig. 15*. Dogwood and glaucous willows at the center (antecedent). Scattered dead pines. Subsequent vegetation consisting of trailing and climbing grapevines, cedar, and bugseed.

undrained swamps, *e. g.*, peat bogs. Schimper even goes so far as to regard peat bog plants as xerophytes, because the humus acids in the soil make it difficult for plants to obtain the requisite amount of water. Consequently peat bog plants have worked out xerophytic structures to reduce the transpiration. All of the swamps at Dune Park are undrained swamps, and may be called potential peat bogs. The chemical nature of the soil is such that the plants have doubtless adapted themselves to all of the essential conditions of a xerophytic life. The partial burial of these plants by a dune results, as has been seen, in no rapid change of relations with the water in the soil. The aerial organs, however, are exposed to a greater degree of light and heat by reason of their proximity to the sand. Thus the tendency to transpiration is increased, but the plants may be able to keep it within bounds through the xerophytic structures that have already been worked out in a swamp environment. It is likely, too, that these structures become more and more xerophytic as a result of life on and in the dune.

The theories that have been exploited in the preceding paragraph find, at least, a partial confirmation. The leaves of the three successful species have more or less pronounced xerophytic structure. The leaves of the dogwood are quite strongly pubescent. The willows, however, are more decidedly xerophytic. The leaves of *Salix adenophylla* are very hairy, and the cuticle is thick. *Salix glaucophylla* has leaves with a very thick cuticle, and coated on the under surface with a dense layer of bloom. In the dune form of this latter species the leaves are notably thicker and the bloom more dense. It is the author's intention to make a careful comparative study of the anatomical characters of these plants, and make report in the second part of this paper. All three of the species named above have a remarkably wide range of habitat, occurring on embryonic dunes, arrested dunes and heaths, as well as in swamps and on lee slopes. These shrubs may grow at almost any altitude and show a surprising independence of the water level in the soil. There seems to be scarcely any doubt, therefore, that

that these species are naturally adapted to a xerophytic life, and that, when the occasion arises, still further xerophytic conditions can be met successfully.

The success of the willows and dogwoods on the dunes may be due, in part, to yet another characteristic. It is well known that swamp plants are provided with extensive adaptations to promote aeration. This need is especially apparent in undrained swamps, where the gases necessary for the underground tissues and organs have to be almost entirely supplied from above the surface of the soil. It is in these undrained swamps, too, that the accumulation of peat is so rapid. It seems rational, then, to suppose that tenants of undrained swamps, by adapting themselves to prevent suffocation, have also adapted themselves to withstand burial by sand without injury. Just what is the cause of death, when plants are partially buried by the soil, is, so far as the author knows, an unanswered question. A wide field for anatomical study and physiological experiment lies open along this line. In the meantime the notion that plants of undrained swamps are better fitted to suffer partial burial than are other plants may remain as a tentative theory.

In considering the formation of secondary embryonic dunes, mention was made of *Potentilla Anserina*, *Cephalanthus occidentalis*, and *Polygonum Hartwrightii* as dune-formers under certain conditions. Potentilla and Polygonum are extensively creeping herbs, while Cephalanthus is an erect shrub. All three are swamp plants naturally, and yet able, as has been said, to build low dunes of a slow growth. In like manner they sometimes remain living for a time when a wandering dune encroaches upon them. They are especially plastic where the advance of a dune is relatively slow. Among these plants Potentilla seems to be the most adaptable to dune conditions. Another swamp plant that shows a surprising degree of plasticity is *Hypericum Kalmianum*. This shrub is very common in the undrained swamps of the dune region, and very often finds itself in the path of an advancing dune. Hypericum, like Salix, often forms a marginal fringe about a swamp, and miniature lines of this shrub are frequently to be seen toward the base of an encroaching dune, resembling the line of willows and dogwoods shown in *fig. 15*. Of course, Hypericum has nothing like the plasticity and endurance of Salix; nevertheless it may live for many years if the dune advances slowly. Its capacity for vertical elongation is much less than that of Salix or Cornus, so that a rapid advance would soon cover the plants and cause their death. Near the South Chicago beach is a pool with a dense vegetation of *Scirpus pungens* about its margin. This plant has served to collect a small amount of sand, and is forming a low secondary dune. Although a large portion of each shoot is covered by the sand, there is as yet no sign of etiolation on the aerial parts of the plant.

Since the highest portion of a wandering dune is close to its advancing front, it is evident that a buried forest will gradually become uncovered, as the dune passes on beyond. No scene in all the dune area is more desolate than such a place. It is a veritable graveyard, where the corpses once buried are exposed again. *Fig. 17* shows a pine graveyard which has had a history like this. In the background are several living pines, presumably members of the same forest with the others. Their position at the summit of a hill permitted them to survive, while those at lower levels were buried by the sand. The uncovered pine trunks are directly in the path of the main wind currents, and hence are subjected to the severest action of the sand-blast. The trunks are carved and battered away until the last remnant of the old vegetation passes away forever.

Graveyards similar to those at Dune Park occur on the extensive dune-complex at Glen Haven. The commonest dead tree there appears to be the arbor vitae, though there are occasional dead trees of birch and ash. In addition to the trunks of trees, there is an abundance of resurrected soil lines at all altitudes on the complex. These black streaks in the sand vary greatly in depth and persistence. Doubtless the organic matter thus exposed is sometimes utilized by the scanty vegetation of the complex, but more commonly it is rapidly scattered by the winds.

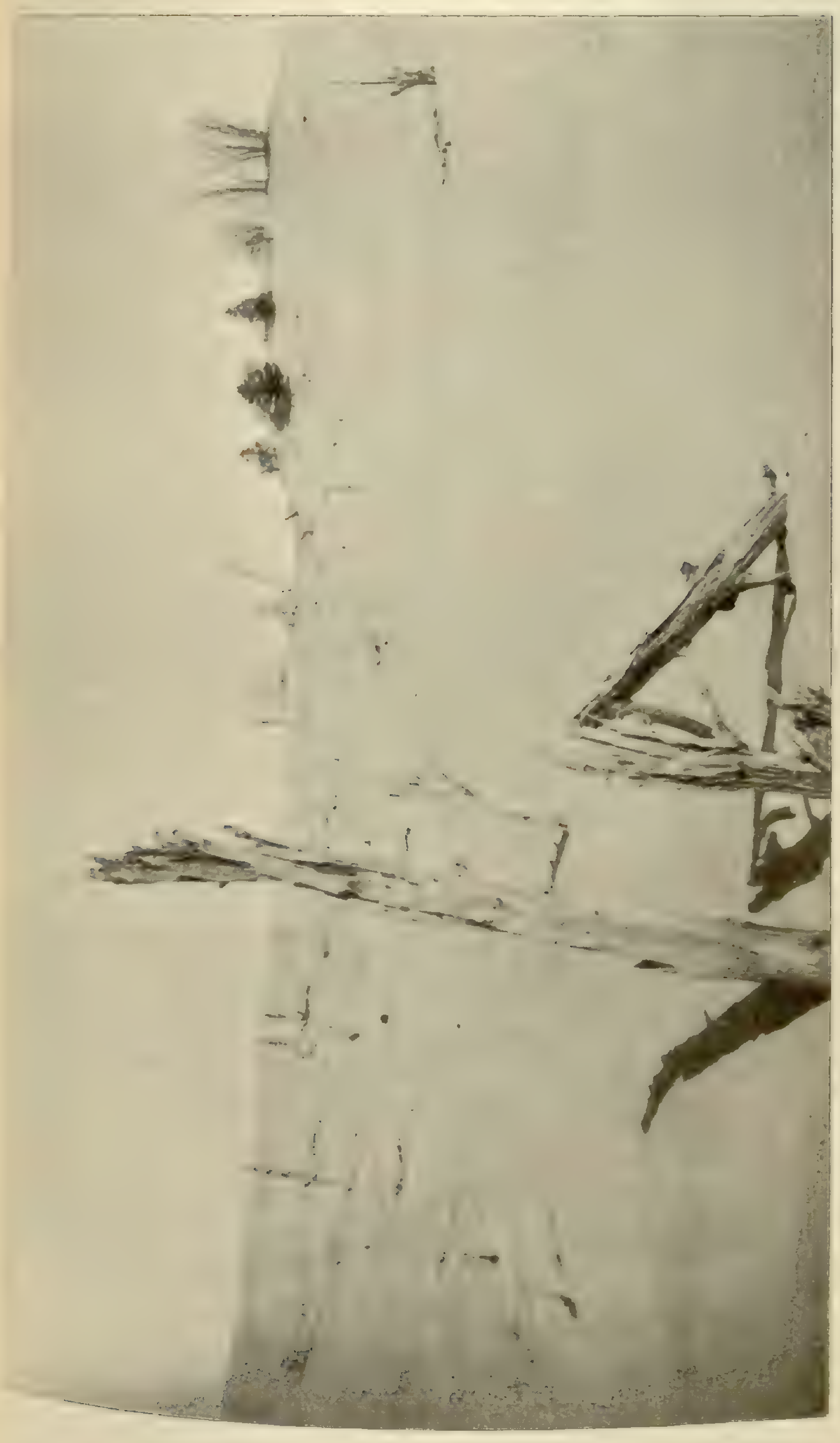

FIG. 17.—Pine graveyard at Dune Park. Forest once buried and destroyed; the dead trees now exposed again. Surviving members of the old pine forest in the background. This area is now a gentle windward slope, and has been converted into a wind-sweep. Carving and battering of the old trunks by sand-blast.

4. *Capture of the dune-complex by vegetation.*

The capture of a dune by plants may begin within the dune-complex itself or along its margin. In either case the first appearance of the advancing vegetation is commonly in the lower places toward the water level. The reasons for this fact are obvious. These low places are well protected from the wind; there is no danger, therefore, of any sand-blast action on the plant organs nor any removal of soil from around the roots. When the growth begins at the foot of an advancing lee slope, there is, however, considerable likelihood that the plants will be covered by the sand. It is this fact which prevents the capture of a rapidly advancing dune; the vertical growth of the plant must be greater than the vertical component of the dune's advance.

The most important reason for the first appearance of plants at lower levels is the soil moisture. It is the moisture at the surface of the soil which causes to a large degree the lodgment of seeds, and especially light cottony seeds like those of the cottonwood and willow. At the base of the dune shown in *fig. 9*, where it is encroaching on a swamp pool, there is a line of young cottonwoods and willows several inches above the level of the pool. The seeds were blown across the complex by the wind; when they reached the crest of the advancing lee slope, they rolled down to the base together with the sand. The base of the dune is always moist several inches above the surface of the water because of capillarity. As soon as the sand and seeds reached the moist soil near the base, the movement was checked and both found lodgment.

The moisture necessary for the germination of the cottonwood and willow seeds is also furnished at these low places near the water level. The danger of being covered by the drifting sand is much less at this place because moist sand is more compact than dry sand, and because moist sand does not collect about the growing plants. The dune shown in the foreground of *fig. 9*, however, is advancing very rapidly, and it is not likely that the growth of the young plants will be rapid enough to prevent their being covered. In the moist sand at the base of the dune shown in *fig. 9* patches of algæ have been seen, presumably Chlamydomonas, such as have been described in connection with the lower beach. It is doubtful if these algæ are of any significance in the capture of dunes.

If the vegetation gets a foothold at the base of an advancing slope, it tends to creep up the slope by means of vegetative propagation. At the base of the cottonwood dune shown in *fig. 5*, there may be seen grasses which appear to be creeping up the slope in this manner. It should be borne in mind that such appearances are often deceptive. In this particular instance the appearance would be the same if the dune were advancing and the grasses rising to keep above the sand. In like manner there is doubt with regard to *fig. 16*, as to which vegetation antedates the dune and which is subsequent. As has been already stated, the clump of dogwoods and willows at the center beyond all question antedates the dune; so too, the dead half-buried pines. The annual bugseeds toward the base, of course, are subsequent.

The greatest doubt is as to the frost grape, *Vitis cordifolia*[4]. At the upper right hand there is a luxuriant grapevine climbing over a dead pine. The clumps back of the willows and the trailing vines in front of them are also Vitis. *Fig. 15* shows several large grapevines back of the row of willows. The coarse-leaved vines at the lower right hand of *fig. 10* are also Vitis. It seems incredible that the vines in this last picture should be anything else than subsequent, since the height of the sand above the wooded hollow is more than twenty meters. Then too the Vitis vines are very abundant all along the coast on the naked dunes, but are rarely found elsewhere. On the dune shown in *fig. 15*, for instance, there are two willows, a dogwood, and the grape growing together. The dogwood and one of the willows are very common in the adjoining swamp, while the grape was not found there at all. On the other hand, no grape seedlings have as yet been found in any such location. While much further study is needed in this connection, it seems likely that Vitis is subsequent to the dune.

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[4] The identification here may be questioned; fruiting specimens are rather rare, but prove to be this species so far as examined.

A little above the center to the left in *fig. 16* is a young cedar, *Juniperus Virginiana.* This little plant is several meters up the slope and is unquestionably subsequent. In the left foreground of *fig. 10* is a shrub of the chokecherry, *Prunus Virginiana*, which is certainly subsequent to the dune. In fact this shrub is rather frequent in such locations. The author does not feel clear as to the conditions which permit the germination and development of these plants in such unstable situations, for it must be remembered that the advance is rather rapid in all cases. No seedlings of the cherry, grape, or cedar have been seen in any such location. It may be that the germination and early growth took place when there was a temporary lull in the advance or during extremely moist seasons. The question cannot be fully solved without a careful study of marked plants for several seasons.

So far as the capture of the dune is concerned, it is a matter of no moment whether the vegetation is antecedent or subsequent. All contribute together to the common end. Of the plants mentioned thus far, Corispermum (shown in the left foreground of *fig. 12*) is of no value in dune capture, because of its annual habit. *Prunus Virginiana* and *Populus monilifera* are rarely abundant enough on lee slopes to be of much value, especially because they have little or no vegetative propagation. The only plants which seem to thrive and increase their area of control on rapidly advancing lee slopes are *Salix adenophylla* and *glaucophylla*, *Cornus stolonifera*, and *Vitis cordifolia.* None of these, however, flourish except on the protected slopes. They are unable to grow along the crest, and hence unable to check the constant advance of the sand.

Vegetation seems to be unable, then, to capture a rapidly moving dune. No such dune has been seen where the vegetation has secured a greater foothold than is represented in *figs. 15* and *16*. This dune is in no sense captured; indeed, its progress is scarcely checked. The more vigorous plants may retain an uncertain foothold for a long time, and again they may not

So long as the crest is unoccupied by plants, the advance will continue almost without hindrance. The life conditions at the crest are so much more severe than on the slope that vegetation is almost certain to be excluded until the advance is checked by physical agencies. For the capture of a rapidly moving dune, a plant species should have the power of rapid germination possessed by the bugseed, the power of vegetative propagation possessed by the willows, the capacity for growth in height possessed by the cottonwood, or even more than that. The growth of the young plant during the first season should be greater than any of the above, so as to more than counterbalance the vertical component of advance during the period of rest. The life cycle should be of very great length. The plant should be able to endure all extremes of heat, cold, and drought, and all degrees of covering by the sand. No plant species in the Lake Michigan region begins to meet all of these requirements, and, as a consequence, the dunes would advance indefinitely so far as vegetation is concerned.

Various physical conditions tend to check the progress of many dunes. As a dune advances farther and farther from the lake, the effective power of the wind which moves it becomes reduced. The energy is largely spent before the crest of the advancing dune is reached, because of inequalities in its path. The wind commonly builds up other dunes between the lake and the main crest; these dunes serve as barriers, and of course check the advance. Occasionally there are hills in front of the advancing dunes; these check the advance temporarily, at least. The primary cause for a permanent decrease or cessation of movement is the decrease or entire loss of available wind energy. Many wandering dunes never advance rapidly at any period of their life-history. This is because their movement is in some other direction than that of the prevailing wind, or because the full force of the prevailing wind is not directed toward their advance, because of physical reasons. Dunes of this slowly moving type are much more common than the other, and may be seen at almost any point along the entire southern and eastern shore.

Whatever the cause, a slowly advancing lee slope is soon captured by vegetation. The process begins just as described above. Vegetation gets a foothold at the base and creeps up the slope Antecedent plants, like dogwoods and willows, increase their area by vegetative propagation. Annuals, biennials, and even the hardier perennials germinate and successfully develop at all points. There are many plant species whose power of vertical growth is greater than the vertical component of a slow dune's advance. This latter condition is always the chief test which determines the vegetation of a lee slope. As the advance becomes slower, more and more plant species are able to get and retain a foothold on the dune.

The capture of lee slopes by vegetation was well seen in all its stages at Glen Haven and Grand Haven. At first the vegetation may be dominantly antecedent, as in the case at Dune Park. More commonly, however, the vegetation is chiefly subsequent from the start, chiefly because the area that is encroached upon contains no plants that are fitted for a dune life. Where there is no antecedent vegetation, the first plant to get a foothold is commonly *Ammophila arundinacea*. Plants that follow in quick succession are *Asclepias Cornuti*, *Equisetum hyemale*, *Calamagrostis longifolia*. Some dunes are almost completely covered with a dense growth of Ammophila. All of these plants are perennial herbs and all but Calamagrostis have very extensive vegetative propagation, so that the capture of a slowly moving dune is a relatively quick process. With these plants there may grow annuals and biennials, but they are of little or no value in dune capture. The commonest of these is *Corispermum hyssopifolium*.

Before many years have passed shrubs and small trees find an entrance and gradually drive out the herbaceous vegetation described in the preceding paragraph. These herbs are all fitted to grow in the most exposed situations, but are not adapted to shade. The shrub vegetation of arrested lee slopes may be partly antecedent, but not largely so. The most common species of shrubs on recently captured slopes are *Cornus stolonifera* (or *C. Baileyi*), *Salix adenophylla* and *glaucophylla*, *Vitis cordifolia* and *Prunus Virginiana.* With these shrubs young trees of *Tilia Americana* are common. A lee slope thicket of Cornus, Tilia, and others of the above plant species is shown at the upper left hand of *fig. 10.*

All of the species named above occur on arrested lee slopes along the entire coast. The species which are peculiarly characteristic of such habitats are Cornus, Prunus, Equisetum, and Asclepias. These four species are found in other associations, but reach a decided climax here. Ammophila, Calamagrostis, Corispermum, Salix (both species), Vitis, and Tilia are almost as common, but have a much wider habitat range. Ammophila, Calamagrostis, and Corispermum are also found in nearly all plant societies thus far discussed, but they disappear entirely as soon as the vegetation becomes dense. The willows are common in many places on the beach and complex, but they too are ruled out as soon as a real forest vegetation gets a start. Vitis grows also on rapidly moving lee slopes, and remains after the forest has begun. Tilia more than all others looks to the future; as will soon be shown, it is the dominant tree of the first forests that grow on the old lee slopes. With the entrance of the basswood, the true dune conditions and the true dune plants are obliged to pass away.

There are other interesting plants that get an occasional foothold on the arrested lee slopes. At several such places at Glen Haven *Betula papyrifera* was seen. Near Chicago this tree does not grow on the dunes at all, although common along the margins of sloughs. It appears to become more xerophytic northward. Exactly the same is true of *Thuya occidentalis.* Possibly the climatic conditions northward are such as to permit plants that grow normally in protected situations to grow where the exposure is much greater. On an arrested dune at Glen Haven where shrubs for some reason are infrequent, *Solidago humilis Gillmani*, *Aster laevis*, and *Achillea Millefolium* grow abundantly with the herbs previously mentioned.

Before tracing the further growth of vegetation on lee slopes, something may be said of the origin and development of vegetation within the dune-complex. Of course all antecedent vegetation has been long ago destroyed. The capture of the dune must, therefore, be effected entirely by means of plants which germinate and develop on the complex itself. Speaking broadly, the complex is almost entirely composed of windward and leeward slopes. Since the windward slopes are low, it follows that they cover a much larger area than do the other. Perhaps nine tenths of an ordinary dune-complex is directly exposed to the prevailing wind. The capture of any portion of the windward slope is unlikely, because of the combination of exposure and instability of soil. In the summer a somewhat extensive vegetation may develop, made up largely of annuals and biennials. The most abundant of these plants is *Corispermum hyssopifolium.* Other species are *Artemisia Canadensis* (or *A. caudata*), *Cakile Americana*, *Euphorbia polygonifolia*, *Cnicus Pitcheri.* These plants are commonly more abundant in the deeper wind-sweeps than elsewhere, probably because the sand is moister and more stable in the sweeps than at other places. *Fig.* 7 shows a very characteristic wind-sweep with its vegetation composed of the bugseed and other short-lived plants.

Although the summer winds are much less severe than those of winter, the effects on the vegetation of the wind-sweeps are often conspicuous. Artemisia and Corispermum plants frequently have the sand blown away from their roots and they are thus obliged to lean over on the sand. The stems become much twisted and the whole plant is shorter and more compact than when developed in more protected habitats. Occasional perennials that may germinate in such places rarely live over the winter. The vegetation develops anew each year and no steps toward capture are taken. The conditions on the lee slopes of the complex are much like those on the main advancing slopes. Of course all of the vegetation is subsequent. The conditions are, perhaps, more severe because more uncertain. Large slopes covered with Ammophila are common on the Glen Haven complex. Permanent capture may sometimes result on such slopes, but it is much rarer than at the slowly advancing edges of the complex.

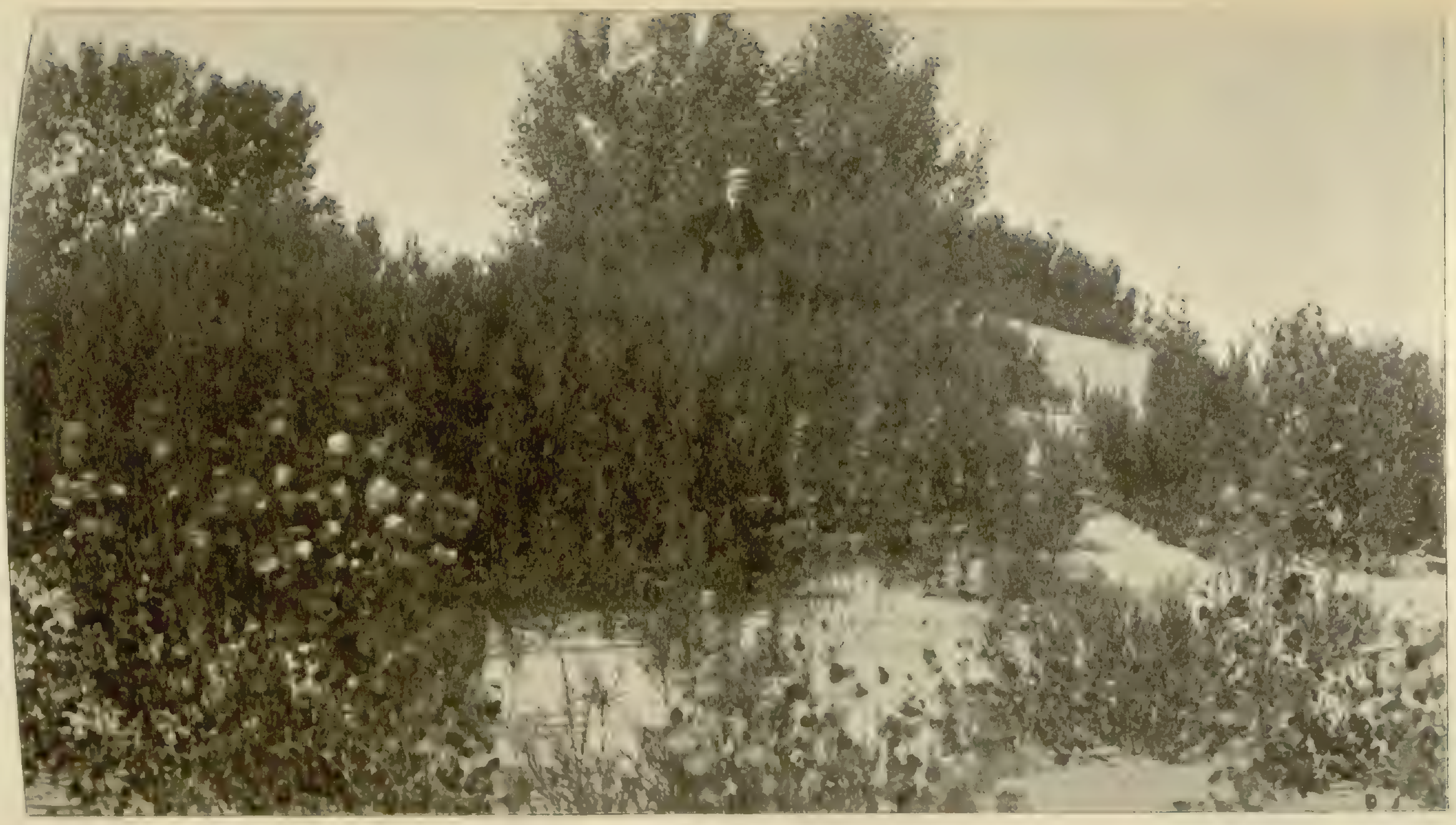

FIG. 18.—Lee slope on the dune-complex at Dune Park, captured by the long-leaved willow, *Salix longifolia*, and the cottonwood (broad-leaved forms). Dense clumps of the willow due to vegetative propagation.

The most important development of vegetation on the complex is in the "blowouts," or hollows produced by the wind. These depressions sometimes reach down almost to the water level and may be as much as thirty meters below the general level of the complex about them. In these depressions the sand is moist and protected from the severest action of the wind, so that seeds find ready lodgment and a favorable opportunity for germination and growth. The commonest plants observed are the annuals and biennials mentioned just above, and the followlowing perennials: *Populus monilifera*, *Salix longifolia*, *adenophylla*, and *glaucophylla*, *Juncus Balticus littoralis*. Seedlings of the cottonwood and the three willows appear by the thousand, and a large number survive the rigors of the winter. This is the one dune habitat where Juncus and *Salix longifolia* are at all abundant. These two species are marvelously well adapted to inaugurate dune capture. Both of these plants have very extensive powers of vegetative propagation. Rootstocks of this last-named willow often trail along in the sand for ten, twenty, or thirty meters. Thus the plants extend their area up the slopes of the depression on all sides by means of this vegetative increase. *Fig. 18* shows a lee slope on the complex, which has been almost entirely captured in this way. The dense clump of narrow-leaved shrubs at the center is *Salix longifolia*, probably all coming from one or two plants that have spread vegetatively. The broad-leaved shrubs and trees are *Populus monilifera*.

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[*To be concluded.*]

BRIEFER ARTICLES.

ULVELLA AMERICANA.

(WITH PLATE VII)

Ulvella Americana, n. sp.—This form was found with Nitella and Œdogonium near Ann Arbor, Mich., and grew in great abundance on the sides of the glass of a small aquarium in which these algæ were growing.

Though it was found in shallow fresh water at a great distance from land, it undoubtedly belongs to the marine genus Ulvella, the only other known species of which, *Ulvella lens*, was first found by the Crouan brothers in 1859, growing on bits of glass, porcelain, and seaweeds, at a depth of twenty meters in the bay of Brest in France. It has also been found by Hansgirg in several places in the Adriatic sea.

The Messrs. Crouan[1] describe the genus as follows: Thallus green, disk-shaped, $1–2^{mm}$ in diameter, horizontal, adhering by all its under surface, composed at the center of cells round, ovate or angled, embedded in a subgelatinous substance, reticulated, and containing in the interior several sporidia. Toward the periphery the cells change to ovoid or rectangular, are much smaller, separated, and arranged in radiating lines either simple or forked at their extremities. A vertical section of the thallus shows the cells to be arranged in almost perpendicular series, and filled with green.

In addition to this description De Toni[2] states that the cells are 12 to 18 μ (rarely 21 μ) in diameter; also that it reproduces by means of zoospores. These are formed in the central cells, 4, 8, or 16 in each, and are liberated by the dissolving of the membrane. According to Wille,[3] however, this is a doubtful genus, as he thinks it might belong to the genus Pringsheimia; but the structure of the chromatophore and the absence of gametes must separate it from this genus, and so the name Ulvella will be retained.

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[1] Crouan frères, Ann. d. Sci. Nat. Bot. IV. **12**: 288. 1859.

[2] De Toni, Sylloge Algarum **1**: 148. 1889.

[3] Engler & Prantl, Die nat. Pflanzenfamilien I. **2**: 105. 1890.

Whether this fresh water form is the same species as the marine form is difficult to say, but it would seem that there were differences great enough to make a new species. Certainly in this form there is much less difference in size between the central and peripheral cells than that figured by the Crouan brothers. Also, in quite a number of cases, long gelatinous looking hairs extended from the surface, and a pyrenoid is always present. As these points seem to be characteristic of the fresh water form only it seems best to separate it from *U. lens*, and to make a new species.

In appearance this fresh water species resembles greatly *Coleochæte scutata*, but the absence of all differentiated sexual organs, the presence of many chromatophores instead of one, and the fact that 4, 8, or 16 zoospores may be found in a single cell of the thallus, all indicate that the nature and development are quite different from that genus.

The disk-shaped thallus varies from 1–3^{mm} in diameter, and until it is partly grown it consists of a single layer of cells arranged in radial rows about a center (*fig. 1*). In surface view the cells near the margin are either square, elongated, or wedge-shaped in outline. They vary in length from 10 to 27 μ, and in breadth from 5 to 13 μ. At the center they are nearly circular, and their diameter is 10 to 13 μ. In cross section the appearance is reversed; the cells near the edge being short or flattened (*figs. 2* and *4*), and those at the middle much elongated, their longest diameter being at right angles to the plane of the disk (*figs. 2* and *3*). The whole thallus does not remain in contact with the substratum throughout its life, but while it is still quite small the central cells become loosened from beneath, then increase in size and number so that the whole center arches up above the level of the disc, and often becomes folded in circles between the center and the periphery. Soon division occurs in these cells parallel to the plane of the thallus, so that at the center several layers may be observed (*fig. 5*).

The membrane is gelatinous, though the layer bounding the contents of the cell is more dense than other portions. Neither the gelatinous substance nor the denser membrane shows a blue color either with chloriodide of zinc or with iodine and sulfuric acid. Both become stained with hæmatoxylin, but not with eosin.

So far as was observed, after the first few divisions only periclinal divisions occurred; even new radial rows of cells originated in this way, one or more projections, occurring on the exterior side of the cell, being then cut off by transverse walls. The long gelatinous hairs observed in the material from the aquarium disappeared in smaller cultures.

The chromatophores, of which there are many in each cell, are small oval bodies closely crowded near the membrane and imbedded in a highly refractive, almost gelatinous looking, liquid. Whether this is simply the protoplasm which surrounds all chromatophores, or whether it is of some special composition was not determined. A single pyrenoid is present near the middle of each cell, and this is surrounded by a starch envelope, somewhat irregular on the surface. The nucleus lies near the pyrenoid, and assumes more or less the shape of the cells in which it exists; that is, in the peripheral cells it is nearly spherical, while in the central cells it is elongated.

Though a disk shape is characteristic of the species when attached to some solid substratum, it is by no means necessary to the plant, and seems to be assumed only when the plant is attached. If it become detached (and it seems to be capable of living indefinitely in this condition), the whole thallus loses all symmetry of structure, and forms simply an irregular mass of cells the same as is noticed when the central portion becomes loosened from the substratum. If a plant be removed from the surface of the glass and put into a hanging drop culture, either in water or in Knop's solution, there occurs an immediate elongation of the cells perpendicular to the plane of the disk, and they stand up, papilla-like, over the whole surface, even at the edge where the cells had been most flattened. In one instance, within four days, division parallel to the plane of the disk had occurred in these cells, and these again divided in all directions, so that the surface of the disk was then covered with little clusters of cells without the least regularity of arrangement, each cluster leading an independent existence (*fig.* 6).

The same holds true if the development be watched from the zoospores. If these become attached on coming to rest the characteristic disk-form is produced (*figs. 7, 8*), but if they rest on the surface of the liquid, or if they rest on a substratum less solid than glass, such as agar, then the development is identical with that when the mature thallus is detached from a solid substratum, except that the cells become somewhat larger, ranging in diameter from 13 to 23 μ (*figs. 9–12*). Division occurs in these cells rather irregularly. A wall may divide the cell into equal or unequal parts, while in other cases one or two parallel projections are sent out, and these are cut off by transverse walls (*fig. 12*).

Although the plant may be kept under cultivation as a unicellular alga for a period of at least three months, evidently the normal state is a disk form, for, though development in the unicellular condition was very rapid for the first few days, it soon decreased and almost ceased. This slow development is true also of the thalli arising from the zoospores when unattached; they never attain a large size, but this may be due to unfavorable culture methods.

Of different culture media tried, water, various concentrations of Knop's solution, vegetable solution, and agar to which had been added Knop's solution, the last medium proved most favorable, and development, though slow, was evident as long as the cultures were continued.

Reproduction other than by means of zoospores and vegetative division was not observed.

The zoospores (*fig. 13*) are oval or nearly spherical, though sometimes more elongated and slightly broader near their anterior extremity (*fig. 14*). They are 10.5–15.5 μ long and 7.8–13 μ broad. Usually they do not exceed 10.5 μ in breadth. They are noticeable for their very granular appearance, which is due to the presence of globules of oil; these become darkened by osmic acid, and dissolved by chloroform. On account of the great quantities of this oil the structure of the chromatophore could not be determined, neither could vacuoles or a pyrenoid be detected. A large brick-red eye-spot is prominent near the anterior end, and four cilia are present. Either four, eight or sixteen zoospores are formed from the repeated bipartition of the contents of a cell. They are liberated by breaking through the gelatinous membrane while still enclosed in an inner gelatinous envelope, this, however, is quite invisible without use of reagents. They remain in this membrane for a relatively long period, moving almost continually. Some half dozen of these clusters were observed to move for three hours, but the entire period of motion was not determined. During these movements they were observed to change their shapes, becoming more elongated in form, as in *fig. 14*.

On coming to rest they soon become rounded, and begin to divide. Usually they develop directly into a disk or cluster, as the case may be, but on agar with 0.4 per cent. Knop's solution several cases were noticed where two or four zoospores were formed directly from these cells, before any other division had occurred (*fig. 15*). These zoospores were not seen to be liberated, but they appeared to be perfect, as each showed distinctly an eye-spot.

In the thallus the zoospores are generally formed in the thickened portion near the center and rarely near the edge. Often the whole center of the thallus has produced zoospores, leaving the cells perfectly empty, and many individuals were noticed on the side of the glass that were ring-shaped, as if the center were entirely gone.

Whereas in most other algæ which reproduce by means of zoospores these are usually formed when transferred from nutritive solution to water, or from stronger nutritive solution to weaker, or from agar cultures to liquid, in this species they are formed when the thallus is subjected to any sudden change. As might be expected, they are produced when the disc is transferred from agar to Knop's solution, but they are also produced when transferred from water to Knop's solution, and when transferred from water to agar. They may be formed within twenty-four hours after these changes are made, but often they do not appear until the second day. In some cases nearly the whole thallus was seen to produce zoospores.

After repeated attempts to find the principles governing the production of the zoospores, no results were obtained farther than that, within certain limits, the greater the change of conditions the greater the number of zoospores and the sooner their formation.

Though this alga greatly resembles Coleochæte in appearance, it really is of much lower organization. Its well developed disk form, instead of being inherent in the alga, as in Pediastrum or possibly Coleochæte, apparently is due only to contact, for, whatever the other conditions may be, it cannot be made to assume this form without a solid substratum.

The fact that it so easily reverts to a unicellular state in which there is no differentiation of cells, but each is capable of carrying on all life functions for itself, and the fact that zoospores may arise directly from the germinating zoospores, show a development but little above the strictly unicellular forms. It may possibly be regarded as one of those organisms, as yet so little known, which are transition forms between the lower and the higher algæ, and may assume the nature of the one or the other according to external circumstances.

That it has been found under conditions so very unlike is not easily explained, and the fact that it has been so rarely found, and then in regions so widely separated, is an interesting problem in distribution.—JULIA W. SNOW, *University of Michigan.*

*** The work upon which the foregoing paper is based was done in the spring of 1898, while the author held a fellowship given to the Botanical Department by Mr. D. M. Ferry, of Detroit.

EXPLANATION OF PLATE VII.

FIG. 1. Portion of a thallus. × 300.

FIG. 2. Thallus in cross section. × 66.

FIG. 3. Section at the center of a young thallus. × 875.

FIG. 4. Section at the margin of a young thallus. × 875.

FIG. 5. Section through the center of an older thallus. × 300.

FIG. 6. Portion of the surface of a disk ten days after removal from glass. × 300.

FIGS. 7, 8. Young thalli developing when attached to glass. × 875.

FIGS. 9–12. Young thalli when not attached to some solid substratum. *Fig. 9*, × 300; *figs. 10–12*, × 875.

FIG. 13. Zoospores. × 875.

FIG. 14. Shape sometimes assumed by zoospores before liberation and occasionally retained after liberation. × 875.

FIG. 15. Zoospores arising directly from germinating zoospores. × 875.

RECENT WORK ON THE LIFE-HISTORY OF THE RHODOPHYCEÆ.

IN Oltmanns' paper upon the life-history of the Rhodophyceæ[1] we have the most recent general expression of opinion on the difficult problems of sexual reproduction and the attendant phenomena of the development of the cystocarp found in this peculiar group of plants. His is the fourth contribution attempting to cover a broad horizon and dealing with the questions in their totality as illustrated through the entire class. The three papers that preceded his account were by Bornet and Thuret in 1867, Janczewski in 1876, and Schmitz in [illegible]

Of these three papers the first two gave descriptions of the [illegible]ogy and development of the cystocarps of several types, which, for clearness of expression and beauty of illustration, have not been surpassed. One can only express the greatest admiration for the work of Bornet and Thuret, but their investigations, as also those of Janczewski, came before the time of critical cytological study, and consequently

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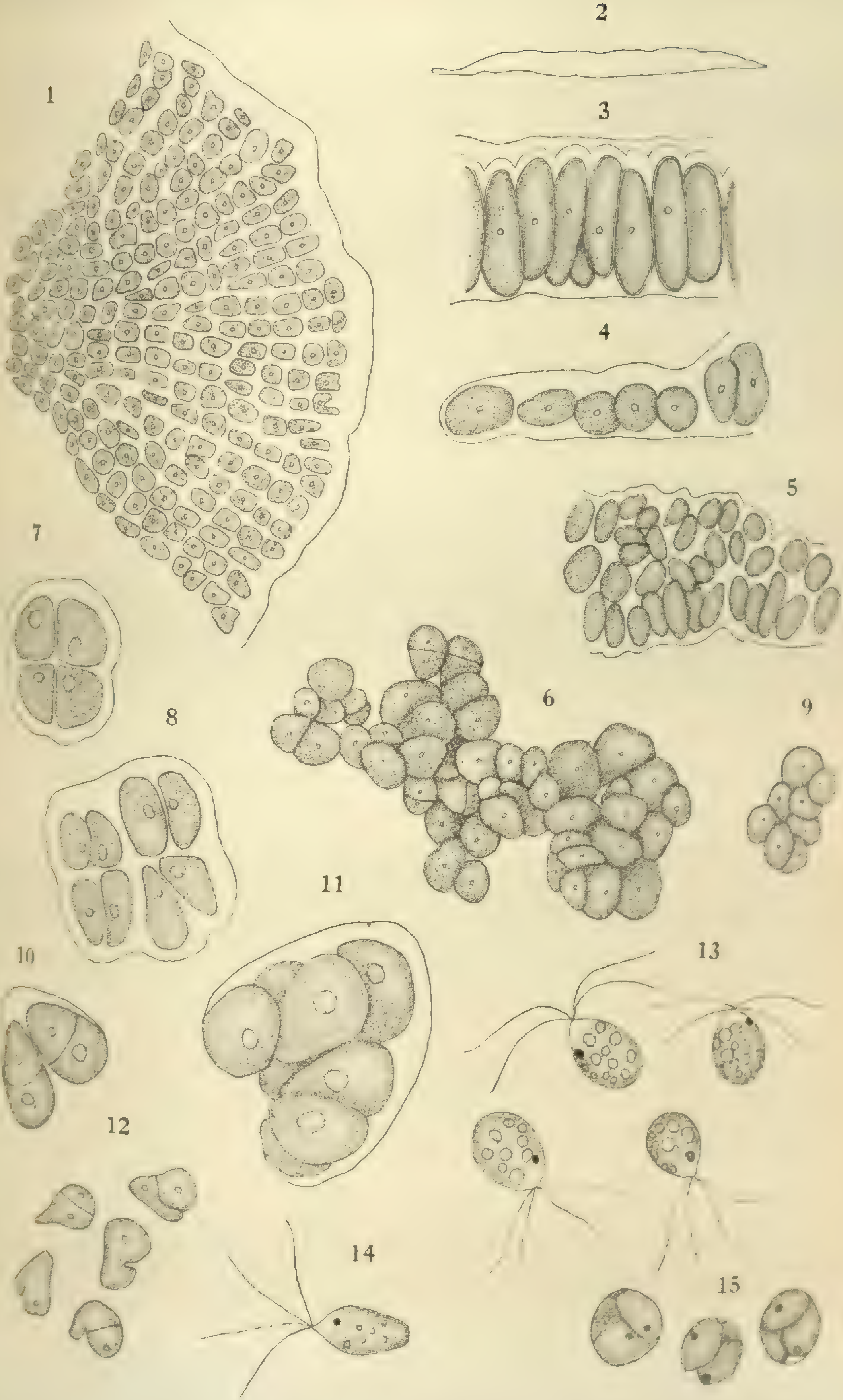
[1] Zur Entwickelungsgeschichte der Florideen. Bot. Zeit. 56^1: 99. 1898.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SNOW on ULVELLA.

made no attempt to describe the mechanism and place of the sexual act, that is, the fusion of sexual nuclei. Schmitz, however, formulated explicit theories as the result of his studies, and gave to the world an explanation, or rather, a set of explanations, describing several types of morphological structure and a variety of physiological conditions concerned with the sexual organs. His views have been dominant until very recently.

The most striking features of Oltmanns' contribution is the manner in which he has swung away from the complex and frequently obscure theorizing of Schmitz, and presented an explanation comparatively simple in the demands it makes upon the facts, and perfectly in accord with the stand that biology takes as to the essential conditions and characteristics of the sexual act. To appreciate thoroughly Oltmanns' views it is necessary that one should know the peculiarities of the theories of Schmitz, and wherein they departed so radically from certain general conclusions of biological science.

It is not easy to discuss so complex a subject in a few words. The difficulties lie in the fact that the Rhodophyceæ present a number of different structural characters in the sexual apparatus, making possible a variety of physiological conditions. Thus there is scarcely one genus that is exactly like another as to the detailed morphology of the sexual organs, and, indeed, species of the same genus often differ among themselves.

When one considers how little precise cytological work has been done in the group and how much lies before the investigator, the possible complications that the future may present are not conducive to a feeling of security for any theory applied universally or even generally.

There are two general statements of facts upon which all investigators agree: first, that male cells fuse with a receptive female apparatus, the trichogyne; second, that certain cells, termed auxiliary cells in many types, are stimulated by this phenomenon to produce carpospores. However, the auxiliary cells hold very various relationships to the trichogynes, and these eccentricities have caused the difficulties.

In the simplest cases, as for example Nemalion, the cell that bears the trichogyne itself develops the glomerule of spores, and observations have been reported, according to which it appears that the sperm nucleus passes down the trichogyne and fuses with the female sex-nucleus in the swollen region of the cell below. It seems clear that the physiological conditions during the processes of fertilization in

Nemalion are those of the so-called oosporic type of reproduction, and are not essentially different from the state of affairs described for such a type as Coleochæte. The differences between the two forms are concerned with the morphology of the antherozoid and oogonium (the latter, by custom, termed a carpogonium in Nemalion), and not with the physiology of the sexual act.

But excepting Nemalion and certain related forms that for the most part have not been studied in detail, the other groups of red algæ present various peculiarities. A few examples will be sufficient to illustrate these curious conditions.

In certain species of Callithamnion there are two auxiliary cells, each giving rise to a separate and independent favella of spores. The carpogonium with its trichogyne occupies a position between the two auxiliary cells, but is not connected with either. Indeed, the three structures may be separated from one another by a considerable space. How is the stimulus of a sexual act, taking place in the trichogyne or carpogonium, to be transmitted to the auxiliary cells and excite their development into favellæ of spores? Oltmanns reports some critical observations upon this problem which for a long time has been very perplexing, and they will be referred to in another part of this review.

Dudresnaya furnishes the best known and perhaps most striking peculiarities. Here the auxiliary cells are situated upon widely separated filaments or branches of the frond and often far removed from the carpogonia. The fertilized carpogonium puts forth several filaments that grow among the loosely arranged vegetative filaments and come in contact with the auxiliary cells. At such points the two elements fuse so that the cell-contents mingle, and here are developed the glomerules of spores. Where does the sexual act take place in Dudresnaya, at the points of fusion between the filaments and the auxiliary cells, or previously in the carpogonium? If fertilization is accomplished in the trichogyne or carpogonium, what is the meaning of the second act of fusion at the auxiliary cells?

There are also a number of instances reported, from genera that are not closely related to one another, in such families as the Gigartinaceæ and Rhodomelaceæ. In these there is present one auxiliary cell close by the carpogonium, with which the latter structure fuses directly or by means of a connecting tube. What is the significance of this single auxiliary cell, and what are the cytological phenomena concerned with the act of fusion?

The chief peculiarity of Schmitz's views lay in his theory of a double fertilization, applied to such forms as have auxiliary cells with the phenomenon of secondary fusion, and typified in Dudresnaya. There were two sexual acts. The first occurred when the sperm cell fused with the trichogyne and its male nucleus entered the carpogonium; but a second act of fertilization took place when the fertilized carpogonium, or the filaments derived from this structure, fused with an auxiliary cell. The development of filaments from the carpogonium that were to fuse with auxiliary cells was a device by which the male nuclear substances could be distributed to a number of such elements, thus multiplying greatly the effects of the sexual act.

The extent to which the theories of Schmitz were developed and perhaps extended by his followers, on what seems today a very inadequate basis of fact, need not be considered in detail here. The accounts of various members of the Chylocladiaceæ by Hauptfleisch, and Schmitz's own view of the fusion plate of Corallina are illustrations to the point. The first author stated that in the forms studied by him extensive and indiscriminate phenomena of cytoplasmic and nuclear fusion took place involving not only the sexual elements but various vegetative cells. The present writer believes that he showed the mistake of supposing that in *Champia parvula* this very general cytoplasmic fusion in the vicinity of the carpogonium was a sexual act. The presence of a variable number of auxiliary cells, instead of one, the great extent of the cytoplasmic fusion concerned with these elements, and the fact of the presence in the cells of a great many nuclei that appear to maintain complete independence of one another, all indicate that the unusual phenomenon is not a part of the sexual act but may well be related to nutritive functions. As for Corallina, preparations show that the fusion plate results from the partial absorption of the walls between a layer of cells below the trichogynes. The nuclei apparently remain in their respective positions, and the idea of an extensive multiple fertilization must be abandoned. It appears that Oltmanns himself, although very friendly to much of the work of Schmitz, is not willing to admit the probability of these flights of theory, quite lacking the basis of detailed observations, in a field of cytology offering extreme and peculiar difficulties. The absence of good figures is a serious defect in the papers of Schmitz and his pupils, particularly as they dealt with subjects acknowledged to be of great complexity.

Oltmanns' studies have led him to conclusions that may be stated very briefly. There is only one sexual act and that occurs in the carpogonium. The structure derived from the fertilized carpogonium is comparable to the sporophyte generation of higher plants. The plant that bears the sexual organs is the gametophyte. Tetraspores are special forms of reproductive cells that have no fixed place in ontogeny. The fusion of the carpogonium or filaments derived from the carpogonium (sporophytic) with auxiliary cells (gametophytic) is for purposes of nutrition. The sporophyte is dependent upon the gametophyte in a manner analogous to the conditions illustrated by the bryophytes.

Indeed, in certain instances, the sporophyte holds a relationship to the gametophyte closely similar to that of a parasite upon its host. The act of fusion between cells of the sporophyte and the auxiliary cells concerns the cytoplasm alone. In all such instances the sporophytic nuclei remain apart from the nuclei of the gametophyte. They never come together and unite, but rather appear to take up positions somewhat remote from one another. The gametophytic nuclei become less prominent as the cystocarp develops, and finally may be very inconspicuous, or even break down and disappear. The carpospores are developed through the activity of sporophytic nuclei, and these are genetically derived from the fusion nucleus that resulted from the copulation of male and female elements in the carpogonium.

These conclusions of Oltmanns are the results of investigations upon four genera of the red algæ, Dudresnaya, Glœosiphonia, Callithamnion, and Dasya. The descriptions are clear, and the excellent figures will be greatly appreciated by those who know the difficulties of this field of study. The evidence would be convincing, were it not for the absence of certain critical stages of nuclear fusion and nuclear division. Perhaps it is not fair to expect such exactness and so much detail in this first presentation of Oltmanns' theories, and the presumptions are certainly in favor of the correctness of his explanations. However, someone must complete the chain of evidence before we can consider the proof as absolute.

The account of Callithamnion is perhaps the most interesting contribution in the paper, since it concerns a well-known and much studied type. Oltmanns finds that the fertilized carpogonium in *Callithamnion corymbosum* divides into two cells, which extend on each side towards the auxiliary cells. A small cell, cut off from each of these on the side nearest the auxiliary cell, fuses with the latter. A sporophytic nucleus is thus introduced into both auxiliary cells and divides near the points of entrance. One of these two nuclei passes to the top of each cell, from which region the favella is to develop. The original nucleus (gametophytic) of each auxiliary cell, together with one of the sporophytic nuclei, finally becomes cut off from the developing favella by a wall and takes no further part in the history of the cystocarp. If these observations are confirmed in other species of Callithamnion the fact will be regarded by the writer as one of the most valuable observations that has been published in this field of investigation; for Callithamnion has presented one of the most difficult problems offered to students of the red algæ. Moreover, the physiological conditions there present seem to be duplicated in a number of genera (Spermothamnion, Griffithsia Lejolisia, etc.). A satisfactory explanation for Callithamnion offers the hope that we may finally understand the complicated organization in a number of other forms.

Time alone will determine how generally the theory of Oltmanns may be applied. The instances of detailed observations on the puzzling conditions of this remarkable group of plants are so few, in comparison to the mass of perplexing phenomena presented, that one may well hesitate before considering Oltmanns' views as established. But it appears to the writer that Oltmanns gives us the most reasonable theory yet presented *in extenso*, the most satisfactory working hypothesis for future investigation, and that its stimulus upon research in this group of algæ will be far reaching.—BRADLEY MOORE DAVIS, *The University of Chicago.*

A NEW SILPHIUM.

IN describing a new Silphium as *S. lanceolatum* in the February number of the BOTANICAL GAZETTE (p. 139) I unaccountably overlooked the fact that Nuttall had used the same specific name in the genus. I therefore propose the name of *Silphium Chickamaugense* for this species.—WM. M. CANBY, *Wilmington, Del.*

OPEN LETTERS.

THE TROPICAL LABORATORY.

Unexpectedly I have had the opportunity of visiting several of the West Indian islands, and of comparing their botanical possibilities in a superficial way. The readers of the Gazette may find of interest a few statements regarding the principal regions, in their bearing upon the tropical biological station which was under consideration.

Jamaica lies six days south of New York, and it requires fifty dollars to pay for the steamer cabin; Trinidad is eight days, and a cabin costs seventy-five dollars.

There can be no question to one who has seen other tropical regions that, while Jamaica has the more beautiful scenery, Trinidad possesses a far more luxurious vegetation. The difference in luxuriance is similar to that between the vegetation of Fiji and Samoa, and does not consist so much in the difference of species as in their development. The valleys and hillsides of Jamaica are covered with the most graceful imaginable patches of bamboo (*B. vulgaris*), standing as monuments to the value of early attempts at plant introduction; the valleys of Trinidad are shaded by gigantic clumps of the same plant which overarch the roads and streams and shade them in the most charming way. Scattered through the gorgeously colored vegetation of the hillsides in Trinidad are innumerable palms, which raise their plumes above the surrounding trees and shrubs; lianas are abundant, and cover the precipitous cliffs like a tattered lace curtain. The streams of Jamaica flow between mountains that are much higher than those of Trinidad; the vegetation of the hillsides is distinctly luxuriant, and, from a scenic standpoint, superior to Trinidad.

Unfortunately for Jamaica the money appropriated for botanical purposes has been expended upon several widely separated stations: the cinchona gardens in the mountains; the old garden at Bath, now abandoned; the Castle gardens, now only cared for by a gardener who spends one day a week upon the ground; and the so-called Hope gardens, within a half hour's ride of Kingston by electric train. The Castleton gardens are well kept and attractive, but quite small, covering only a few acres, and containing a quite limited number of plants. The fine Cohune palms from Central America, teak, brazilnut trees, a Carnahuba palm from Brazil, Heveas, Castilloa, *Manihot Glaziovii* and other rubber-bearing plants, as well as the gorgeous flowered *Amherstia nobilis*, *Spathodea campanulata*, and the familiar East Indian durian, carambola, and mangosteen fruit trees form some of the principal curiosities.

Three small two-roomed cottages and a small eating house on the hill above the gardens are kept by a native hotel keeper. These furnish the only accommodations possible for a visiting botanist in this quite out-of-the-way, secluded spot. A description of the Jamaica gardens has already been published in the GAZETTE by their able director, Mr. Fawcett. The American student would find it difficult to study at Castleton, as there is no laboratory, and carriage hire to and from Kingston would prove rather expensive. All laboratory material would necessarily be transported from Kingston to this isolated spot, as well as in large part the canned goods upon which he would find it necessary to live.

The well-equipped laboratory of the Hope gardens is one half hour from the town of Kingston. The visitor would be obliged to live in the city of Kingston, and go back and forth on the electric car every day. The laboratory is not equipped for all kinds of botanical work, but is an airy, well kept place, which would form a very pleasant laboratory for a herbarium student, and could easily be fitted up with appliances for microtome or physiological work. The hotel at Kingston at which the visitor would be obliged to put up is quite impossible from an American standpoint, and would go a long way toward giving him several sorts of tropical complaints should he stay long.

Port Antonio, on the north coast of the island, possesses no garden, and the Johns Hopkins laboratory, in which Dr. Humphrey contracted the fever from which he died, consisted of several converted rooms in Captain Baker's excellent American hotel, built upon the substantial profits of the banana trade. Port Antonio is a small town, very picturesquely built on the coast, but affording little of interest in the way of native life and characteristic markets in comparison with Kingston. The roads lead directly through cocoanut plantations or banana fields into the mountains, whence material for study would be easily obtained.

In Kingston, the Jamaica Institute, with its good library of West Indian books, the museum of West Indian natural history, and the laboratory of agricultural chemistry, under the able management of Messrs. Duerden, Cundall, and Watts, respectively form a collection of great value to a visitor, enabling him to orient himself quickly in the problems of tropical botany and zoology. So far as official scientists are concerned, Jamaica seems much better supplied than any of the other British West Indian islands. The Agricultural Society, with Mr. Doust in charge, would prove of material assistance to any student interested in agriculture.

The gardens in Trinidad are the largest and best cared for of any it has been my fortune to visit in the West Indies. They are situated beautifully in the open square or "savanna" in the center of the residence portion of the city of Port of Spain. The laboratory is small, but equipped with many of the useful utensils of a working botanist, and a small library of botanical works. Mr. Hart, the director, whose hospitality I cannot fail to mention in this place, is an indefatigable worker, and would put at the disposition of the visitor every facility in his power. His neatly arranged experimental farm, not far from the gardens, has quite the appearance of a young American experiment station, and his breeding experiments on sugar cane and other plants show his keen interest in the coming problems of tropical agriculture.

The roadways, although few, lead at once into the virgin forest, and with the assistance of a bicycle a collector could easily get together an abundance of material for study. Should he wish to take up the study of any of the many problems which confront the agriculturists of the colony, the utmost would be done to assist him, and pecuniary assistance in the way of compensation for the results of his studies would be a possibility.

The Victoria Institute, with its large comfortable building on the other side of the savanna from the gardens, might prove useful should more room be required than is available in the garden laboratory, or the new building of the experimental farm soon to be constructed.

A comfortable hotel, good shops, a public library, a society of English and Scotch, and a most interesting mixture of East Indians, Chinese, West Indian blacks, and Portuguese make Port of Spain a place full of things, other than botanical, to be studied. I am free to say that, as an average American, Trinidad proved much more to my liking than Jamaica, although the latter has roads all over it, and is more picturesque.

From Trinidad excursions can be made up that as yet little known river, the Orinoco, and to the many small islands lying nearer the mainland.

From the standpoint of a superficial study of the two islands I cannot but express my opinion in favor of Trinidad as the place for a botanic station. Should, however, the lately acquired island of Puerto Rico prove more suitable for a biological station, as seems quite possible, certainly any young student of tropical botany cannot afford to neglect the advantage which Trinidad affords as a place in which to become acquainted with West Indian agriculture and botany.

The recent establishment at Barbados of a Department of Agriculture for the West Indies, with Dr. Morris as commissioner, may in time change the conditions there. At present Barbados has little to offer the student.

The islands of the French West Indies and other of the British West Indies have botanic stations upon them, but, so far as my information goes, are not to be considered in connection with Trinidad or Jamaica.

It would seem to the writer as not at all beyond the pocket of many American botanists to spend a summer vacation in Trinidad, and could they realize the enthusiasm which these tropical plants and animals awaken, they would need no urging.—D. G. FAIRCHILD, on board "Canada," at Savanilla, U. S. of Colombia, February 15, 1899.

CURRENT LITERATURE.

BOOK REVIEWS.

Experimental morphology.

THE second part of Davenport's *Experimental Morphology*, which has been awaited with so much interest, has recently appeared.[1] This part deals with the effect of chemical and physical agents upon growth. It will be remembered that there are to be two parts more, devoted to cell division and development.

The general plan of treatment is the same in this part as in Part I, already reviewed in this journal.[2] Since the phenomena of growth have been more studied in plants, in which they are very prominent and yield themselves much more readily to analysis than in animals, the present part includes a more extensive discussion of plants than the first. This part, therefore, will have, if possible, a greater interest for botanists than the first, though the whole work will be of the greatest service to them.

A chapter is devoted to the effect of each agent which exercises an influence upon the rate or the direction of growth. From the chapter on chemical agents, water is excluded, being given a chapter by itself. Molar agents, gravity, electricity, light, and heat, are discussed in turn, and the part concludes with a chapter on the effect of complex agents on growth, and the general conclusions. Each chapter is followed by a bibliography of the more important papers on the subject treated, a feature of very great value to students.

Because of the wideness of the field traversed, it is impossible that such a work as this should be in the main anything but a compilation of the results of the labors of others, and we are glad enough that some one has had the courage to undertake so vast a task. It would be, therefore, somewhat ungracious to expect, much more to demand, the critical use of the great mass of literature. But most readers will expect a thoroughly digested presentation, and the book may be open to criticism in this direction.

A single illustration of this will suffice to indicate the form such criticism might take. In the discussion of traumatropism of roots, the author cites experiments of Pfeffer which, he says, show that "the identical plasm which is irritated responds, producing the traumatic curvature" (p. 386). But in discussing geotropic curvatures, he cites other experiments of Pfeffer, from which he concludes that "the curving part of the root can contain none of the originally irritated cells" (p. 396). These views can hardly be reconciled. It seems to be the first induction which is faulty.

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[1] DAVENPORT, C. B.—Experimental morphology. Part II. Effect of chemical and physical agents on growth. 8vo. pp. xa–xb, xv–xviii + 281–509. *figs. 75–140.* New York: The Macmillan Company. 1899. $2.00.

[2] BOT. GAZ. 23: 467. 1897.

The most notable omission is the absence of any discussion of the theories of growth. This could hardly be other than intentional, but surely every reader will expect at least a presentation of the current ideas as to the mechanics of growth.

Some details may now be adverted to in order that readers may be guarded against indiscriminate acceptance of the author's statements and definitions.

It is doubtful whether clearness of ideas is attained by speaking of the cell sap as "living matter." One might with as much justice include the water secreted outside the cell as that secreted within the protoplasm.

Nor can there be any justification for the association of the phenomena of turgor, as in the motor organs of leaves, with those of true growth, under the phrase "transitory growth." Greater clarity of conception and expression is secured by limiting the term growth to the permanent or irreversible changes of form and volume. The dissociation from growth of certain changes (in the interior of spores, etc.) which do not result in increase of volume (the author's sole criterion of growth) is difficult and of doubtful value. In fact, it is impracticable to establish a single criterion for growth.

The account of the causes of twining is quite inadequate, as the author does not seem to be aware of the more recent experiments on the subject, none since Darwin's in 1882 being cited. The conclusion generally accepted today is certainly *not* that "twining is mechanical — depending upon the structure of the stem — rather than responsive" (p. 377).

The general discussion of the mechanics of tropic reactions is certainly very unsatisfactory. This is partly due, of course, to the present want of knowledge, a fact which might well have received more stress than the author gives it. The assumptions that are made are too many and too bold to be of any assistance in clearing up this very difficult subject. For example: the relations of growth and turgor are too uncertain at present to permit the mechanics of phototropism to be explained through the intervention of turgor. It must first be demonstrated that turgor controls growth, and not growth turgor. Again, the separation of the slow reactions from the more rapid ones, and the assumption that the former are due to "differential imbibition" and the latter to "assimilation," while the ones of intermediate rate "are probably due to the combined action of assimilation and imbibition," is not only gratuitous, but absolutely misleading (p. 481). And surely the author does not mean what he says when he suggests that "the tropic agent causes such a change in the molecules of the curving region as to cause them to imbibe water with abnormal activity" (p. 482).

In spite of such minor defects, which are of importance only to the student whose knowledge is not general enough to guard against them, this part, like its predecessor, must take a high rank among the books destined to advance the knowledge of living organisms. This it will do, not only by making more available an immense mass of important data, and pointing out the source of others, but still more effectively by its suggestiveness as to profitable direction for experimentation.— C. R. B.

The principles of agriculture.

THE authors of books written in illustration and aid of agriculture may be roughly grouped into three classes. First, those who, unacquainted with science, are adepts in practice and have faithfully described their own methods, together with the usages of others who have successfully followed some branch of the business of farming; second, those who have written from the standpoint of pure science; and third, those who combine a practical knowledge of agriculture[3] with a thorough knowledge of the sciences with which the art is intimately related and upon which the best practice chiefly depends.

Professor Bailey belongs to the latter class and his qualifications for writing or editing a text-book treating of the "principles of agriculture" are by no means slender.

Will the book edited and largely written by him, meet the needs of those for whom it is designed? Let us consider.

The general arrangement or plan of the book is excellent. It begins with an appropriate introduction, which defines agriculture and its main subdivisions, discusses the personal factors upon which success depends, and shows the relation of the natural sciences to this great industrial art.

The main body of the book is divided into three parts, viz.: The soil; the plant, and crops; the animal and stock. The six chapters into which part one is divided are written by four different men. Part two has three different authors, and part three has four.

Those who have assisted Professor Bailey in the preparation of this work are his colleagues or associates in Cornell University as follows: I. P. Roberts, James Law, H. H. Wing, John W. Spencer, L. A. Clinton, G. W. Cavanaugh, and B. M. Duggar.

In addition to its logical arrangement the book has the merit of being written in language that few can can fail to understand. The use of terms unfamiliar to the general ear has been avoided, and there are few paragraphs which will not be readily and fully understood by the average school boy of fifteen or sixteen years.

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[3] BAILEY, L. H., *et al.*: The principles of agriculture. A text-book for schools and rural societies. 12mo. pp. 300. Illustrated. New York: The Macmillan Company. 1899. $1.25.

If the book has any weakness it is that it attempts too much. It presents such a vast array of principles, in so brief or concentrated a form, that there is danger of cloying the appetite, or producing mental dyspepsia. Some of the principles named are axiomatic and it seems scarcely necessary to repeat so much self-evident truth. In some cases non-essentials are emphasized and essentials are passed over slightly. By restricting the number of topics, and elucidating the more important principles, the probability of treating them to the average student's profit would be greatly increased.

A book treating of the principles of agriculture can scarcely be called complete which has nothing to say about exchange and distribution. If farming is a business, the machinery whereby the farmer converts into money, or other values, that portion of his products which is not consumed on his farm, and the principles concerned in such exchange, are nearly as important as those concerned in mere production.

It seldom happens that a book which is the joint product of so many different contributors possesses such a clear, vigorous and attractive style throughout as does this one. Scholarship and training are evident in every chapter.

If this book could be placed in the hands of each earnest young farmer, it could scarcely fail to give him a broader, truer conception of what farming really is, and would teach him that thought and study, observation and reflection are just as essential and serviceable upon the farm as elsewhere.

To all those who are resolved to be good farmers we commend this volume, because no man in this age can be a thoroughly good farmer without the knowledge which can be more easily and rapidly acquired here than elsewhere.—W. R. LAZENBY.

MINOR NOTICES.

THE "NEW EDITION" of Hansen's *Pflanzenphysiologie*, bearing date of 1898, seems to be only a re-issue of that well and favorably known book.[4] It was primarily intended for that large circle of readers who are chiefly interested in some other field of science, but wish to have simple, accurate, and concise information concerning the fundamental facts and principles of plant life. This mission it fulfilled well. It would be wise to have the progress which has been made since 1890 embodied in a thoroughly revised edition. To those who do not already know and use the original edition, we commend it as presenting many points in a clear and interesting fashion, with happy citation of examples.—C. R. B.

THE SATISFACTORY reception which has been given to Russell's *Dairy*

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[4] HANSEN, ADOLPH: Pflanzenphysiologie. Die Lebenserscheinung und Lebensbedingungen der Pflanzen. Neue Ausgabe. 8vo. pp. viii + 314. *figs. 160.* Giessen: J. Ricker'sche Buchhandlung. 1898.

Bacteriology[5] has encouraged the author to prepare the fourth edition, which is a thorough revision of the third. The work is divided into three parts; first, the structure, form, physiology and methods of study of bacteria in general; second, the contamination and fermentation of milk, and the proper means of milk preservation; third, the relation of bacteria to milk products, as concerns both their desirable and undesirable effects.

The work is excellent in that it makes practical application of so much of the purely scientific work of bacteriology. It furnishes a further testimony to the mutual relation existing between research and practice. It seems, however, that the book should contain figures of those bacteria found in connection with dairying, which induce not only unfavorable conditions in milk, but also of those which induce diseases of men, since illustrations would better enable students of dairying to identify such organisms when present. It is quite noticeable that so important a work as the *Manual of Bacteriology* by Muir and Ritchie should be omitted from the author's list of works which "contain more or less complete descriptions of the various processes employed in studying bacteriology."

As a text upon dairy bacteriology the book fills a place not approached by any other work, as shown by the fact that it is now used in all the dairy schools of the United States and Canada. In addition to the interest in the book on the part of students of such schools, the subject is of so much importance to all users of milk and its products, and the book is so excellently written that it should be extensively recommended to all as a study in public hygiene. —Otis W. Caldwell.

NOTES FOR STUDENTS.

Fascicles III and IV of the *Fungi Rossiæ Exsiccatæ* contain a number of interesting Uredineæ collected by Mr. Komarov in Mantchuria, and included because the flora is similar to that of some of the Russian provinces. As the plants of that region are so closely related to those of eastern America, it was to be expected that some of our parasitic fungi would occur there. Accordingly we find *Puccinia Waldsteiniæ* Curt.; *P. haleniæ* Arth. & Halway, hitherto only known from northern Minnesota; a variety of *P. heucheræ* (Schw.) Diet.; *P. mesomegala* Berk. & Curt.; *Æcidium Sambuci* Schw.; and *Uromyces lespedegæ* (Schw.) Pk.—E. W. D. H.

The February number of *Natural Science* is an interesting, if not in all instances a gratifying, one to students of ecology, containing, among other things, papers on the study of plant associations by Robert Smith, mimetic resemblances in animals and plants by Professor Henslow, and bees and the origin of flowers by G. W. Bulman. The first is chiefly interesting because of an analysis of the earlier treatment of plant formations or associations; Professor Henslow concludes, after an employment of the expressions "mimicry" and "mimetic," which is rather different from that usual with naturalists, that "natural selection is quite uncalled for, and, in fact, has no *raison d'être* in the origin of any structure whatever;" and Mr. Bulman reaches the conclusion that the theory of the origin of flowers by the selective action of insects, "as taught by Darwin, Wallace, Hermann Müller, Sir John Lubbock, and Mr. Grant Allen, is absolutely incompatible with the facts of the mutual relations of insects and flowers."—W. T.

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[5] Russell, H. L.: Outlines of dairy bacteriology. 4th ed. pp. vi + 190. *figs. 39.* The Author, Madison, Wis., 1899.

IN A PAPER[6] reviewed in an earlier number of this journal,[7] Oltmanns claimed to have disproved the earlier work of Berthold,[8] according to which, in *Ectocarpus siliculosus*, a quiescent female gamete becomes attached to several male gametes, with which it is said to fuse. Basing his conclusions upon a study of *E. criniger*, Oltmanns claimed that Berthold saw, not fusing gametes, but infusoria capturing and eating the algal zoospores. Berthold replied immmediately,[9] insisting that his preparations were not susceptible of any interpretation other than the one he had already given.

Recent work by Oltmanns[10] upon *E. siliculosus* has led him to abandon his former position, and to confirm the statements of Berthold. He indeed finds infusoria, as before, but he also finds gametes fusing, and described the process quite fully.

Several male gametes become attached to the female by their long anterior cilia; finally one is drawn nearer, and fusion follows. In material collected in the morning this generally occurs before noon, and nuclear fusion is usually completed before night. The fusion of the female with more than one male gamete is very rare, but the author does not tell us of the fate of the second male nucleus when this occurs. The second chromatosphere of the normal zygote is said to persist.

We may then say that the Ecocapaceæ show sexual conditions in all stages of transition from isogamy, through such forms as *Ectocarpus siliculosus*, in which there is hardly more than a physiological differentiation of the gametes, to the distinct heterogamy of *E. secundus*, in which, according to Sauvageau, the two gametes differ considerably in size.

The "neutral" swarm-spores which are almost always associated with the gametes in the plurilocular sporangia, arise secondarily by the failure of sexual fusion, and therefore do not stand in a close phylogenetic relation to the swarm-spores of the unilocular sporangia.—W. D. MERRELL.

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[6] Flora **83**: 398–414. 1887,

[7] BOT. GAZ. **24**: 383–384. 1897.

[8] Mittheil. d. zool. Stat. Neapel **2**: 401. 1881.

[9] Flora **83**: 415–425. 1897.

[10] Ueber die Sexualität der Ectocarpeen. Flora **86**: 86–99. 1899.

NEWS.

Mr. M. A. Carleton is on his way back to America after a tour through Russia under the auspices of the U. S. Department of Agriculture.

MM. Casimir and Lucien de Candolle have presented to the University of Geneva a bronze bust of Alphonse de Candolle, the work of the sculptor Bovy.

Dr. Bengt Jönsson, previously docent, has been appointed assistant professor of botany in the University of Lund, in charge of anatomy, physiology, and ecology.

Mr. A. A. Heller, who is collecting in Puerto Rico, reports good success. He finds the roads excellent, making it very easy to reach all parts of the island by using a bicycle.

Dr. M. Raciborski has left the Experiment Station for sugar cane in Kagok Tegal and has been appointed to a post at Buitenzorg, in charge of investigations upon tobacco.

Mr. B. T. Galloway has returned to Washington, D. C., from an extended visit in California, where he had gone to regain health. He returns much improved, and is able largely to resume his duties as Chief of the Division of Vegetable Physiology and Pathology.

Dr. Richard Wettstein, Ritter von Westersheim, professor of botany in the German University of Prag, has been called to the professorship of systematic botany in the Imperial University of Vienna as successor to the late Anton Kerner, Ritter von Marilaun.

The museum and laboratory building in the New York Botanical Garden is making fair progress toward completion. It is now entirely enclosed, and the partition walls and other rough interior work are mostly finished. The present outlook indicates that it will be ready for occupancy late in the spring. The foundations for the glass houses will be laid when the ground is free from frost.

Our note in the March number regarding the fire at the University of Geneva, based upon information obtained from *Nature* and the *Gardeners' Chronicle*, was fortunately incorrect. The Delessert herbarium was not housed in University buildings but at some distance, and it is unharmed.

Correspondents inform the *Gardeners' Chronicle* that "the fire broke out in the left wing of the University, and destroyed an apartment in which were some collections, diagrams, etc., relating to the Alpine flora, belonging to Professor Chodat. Some loan collections from foreign herbaria were likewise destroyed, as well as some physical instruments that had belonged to De Saussure."

THE historico-biographical work, entitled *The botanists of Philadelphia and their work*, by Dr. John W. Harshberger, instructor in botany in the University of Pennsylvania, is now ready for the press. It will be printed as soon as sufficient subscriptions have been secured. Philadelphia in colonial days was the scientific and literary center of Amercia and the botanists of Philadelphia did much good and lasting scientific work. The book is a contribution to the history of the rise and development of botany in America; for many of our early botanists of historic importance were Philadelphians. It is to be illustrated by about fifty full page portraits.

WILHELM ENGELMANN, Leipzig, announces that he will begin publishing, in the course of the year, a work by Dr. C. G. De Dalla Torre and Dr. H. Harms, entitled *Genera Siphonogamarum*. It is to present a synopsis of the orders, families, genera and sections of the spermatophytes based upon Engler and Prantl's *Natürliche Pflanzenfamilien*. The important synonymy, references to the basal work, and various other conveniences are promised. Such a book will be a great convenience to systematists, and will be especially useful in arranging herbaria in accordance with a modern system. It will take a place similar to Durand's *Index Phanerogamarum*, which was based upon Bentham and Hooker's *Genera Plantarum*. The work will be issued in ten parts, of about 160 pages each.

THE FIELD WORK in the southern Rocky mountains, carried on in the La Plata region in 1898, by Messrs. Baker, Earle, and Tracy, will this year be extended into the San Juan region, the extreme eastern extension of the Great Basin watershed in southwestern Colorado and northwestern New Mexico. Last year the field work was limited to a month, and the plants were determined and issued under difficulties. However, they included many new phanerogams, while a third of the fungi were new. These sets went to the herbaria of Edinburgh, Kew, Berlin, New York, Washington, Chicago, St. Louis, and others. A full report of the 1898 work by Dr. E. L. Greene and Professor F. S. Earle will soon be issued. This year the field work will continue through the entire season in charge of Mr. C. F. Baker (now at St. Croix Falls, Wis.). A full report of results will be published as for 1898, and issued free to subscribers. If complete sets are not desired, selections may be made by groups or by single specimens.

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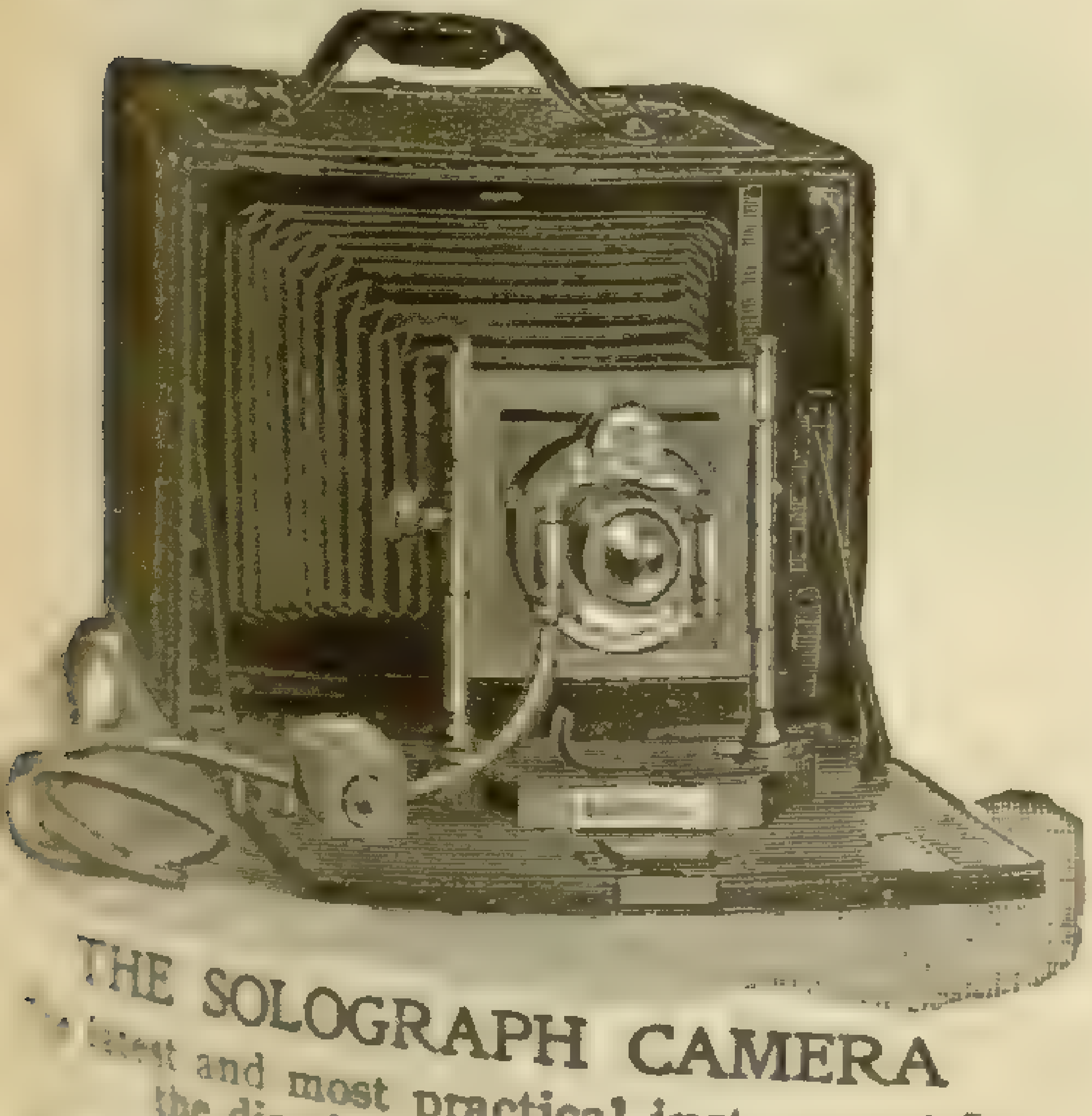

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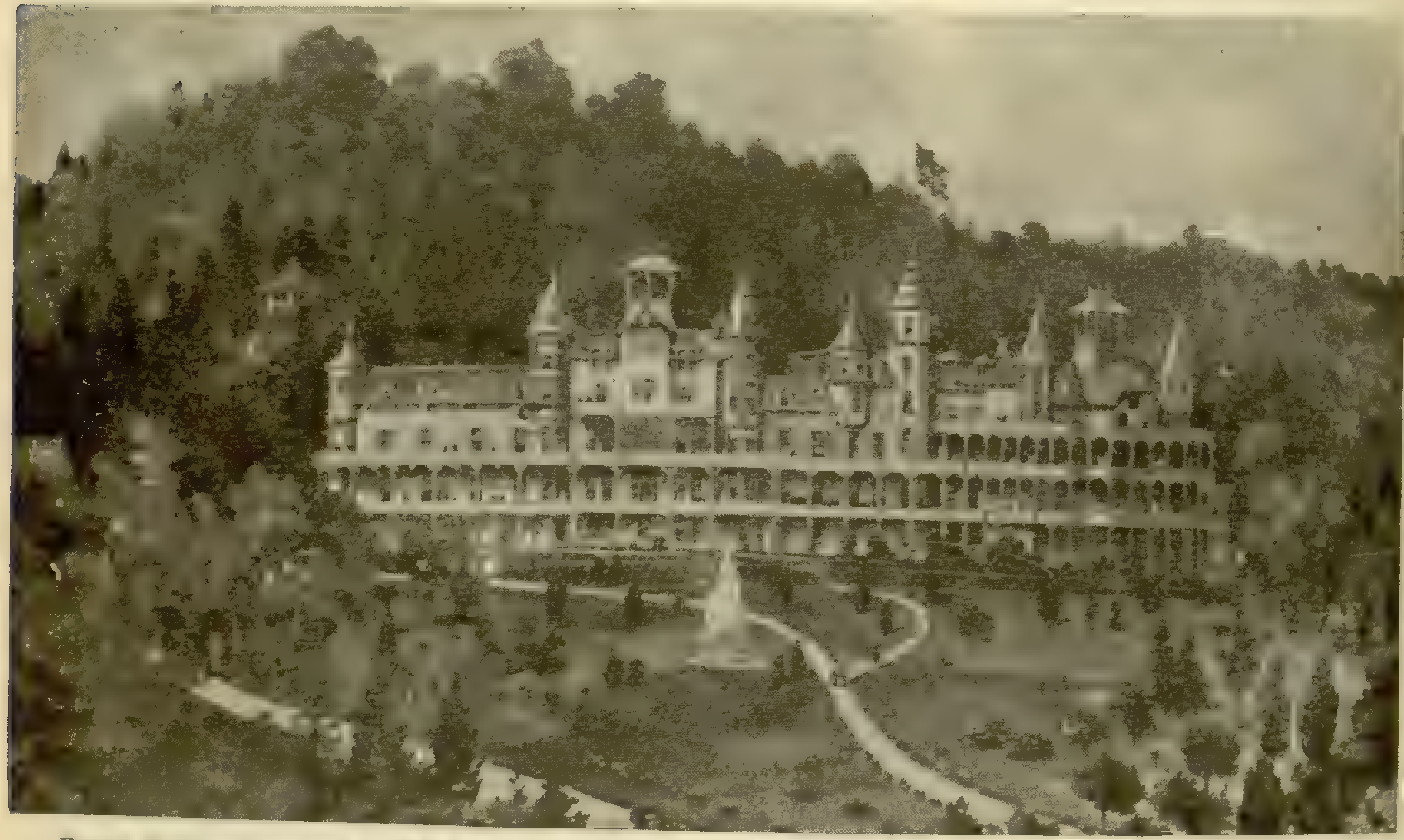

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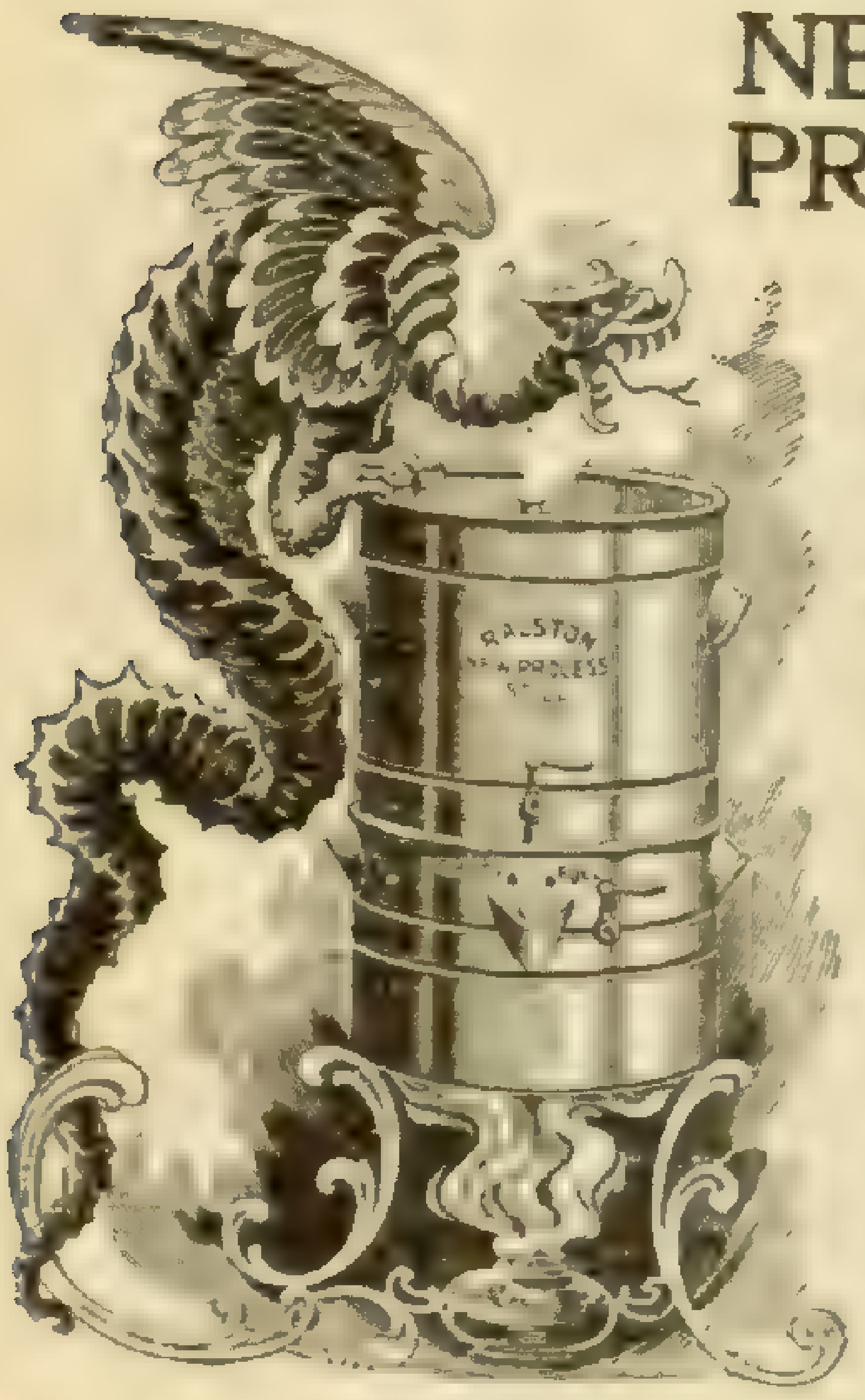

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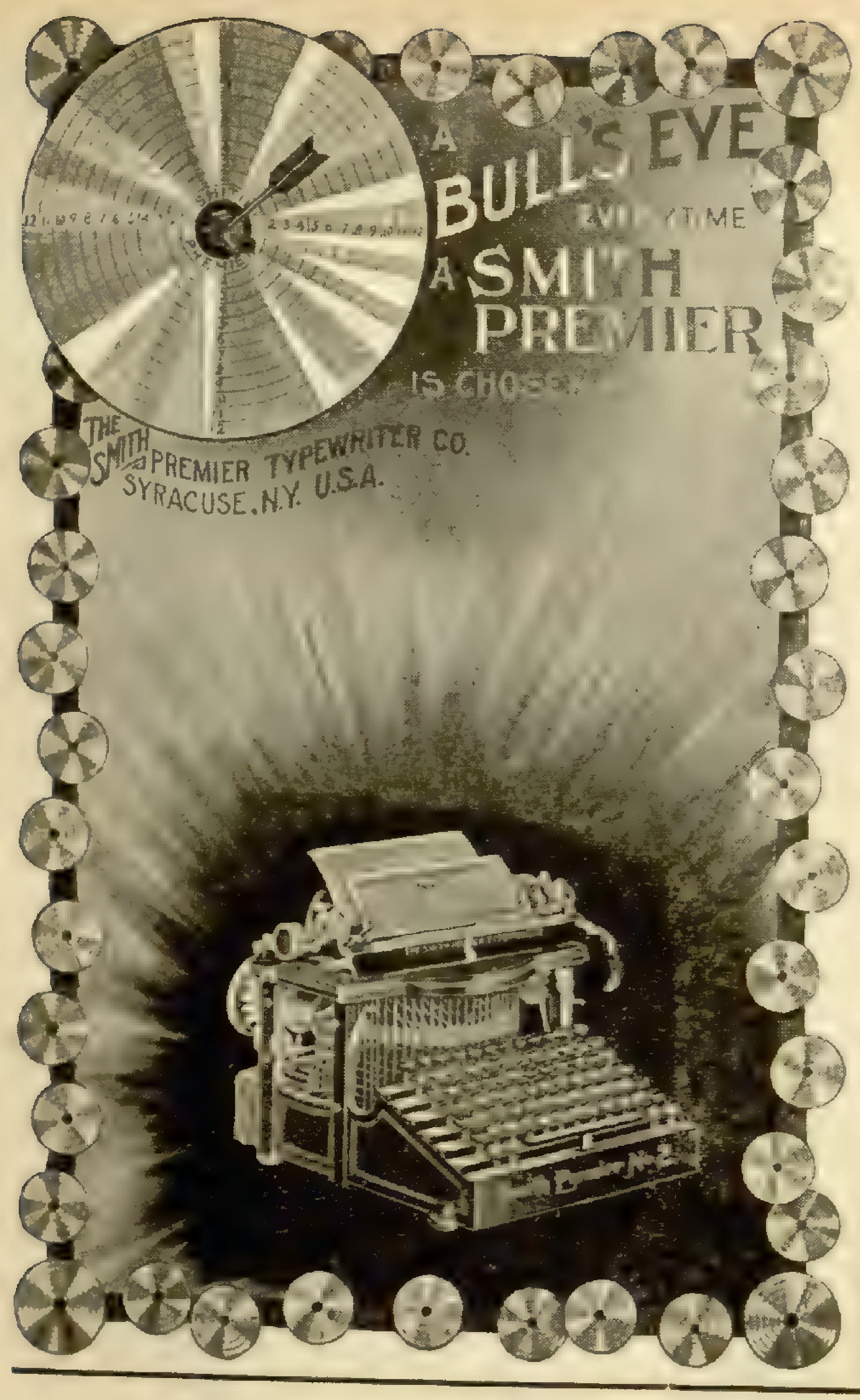
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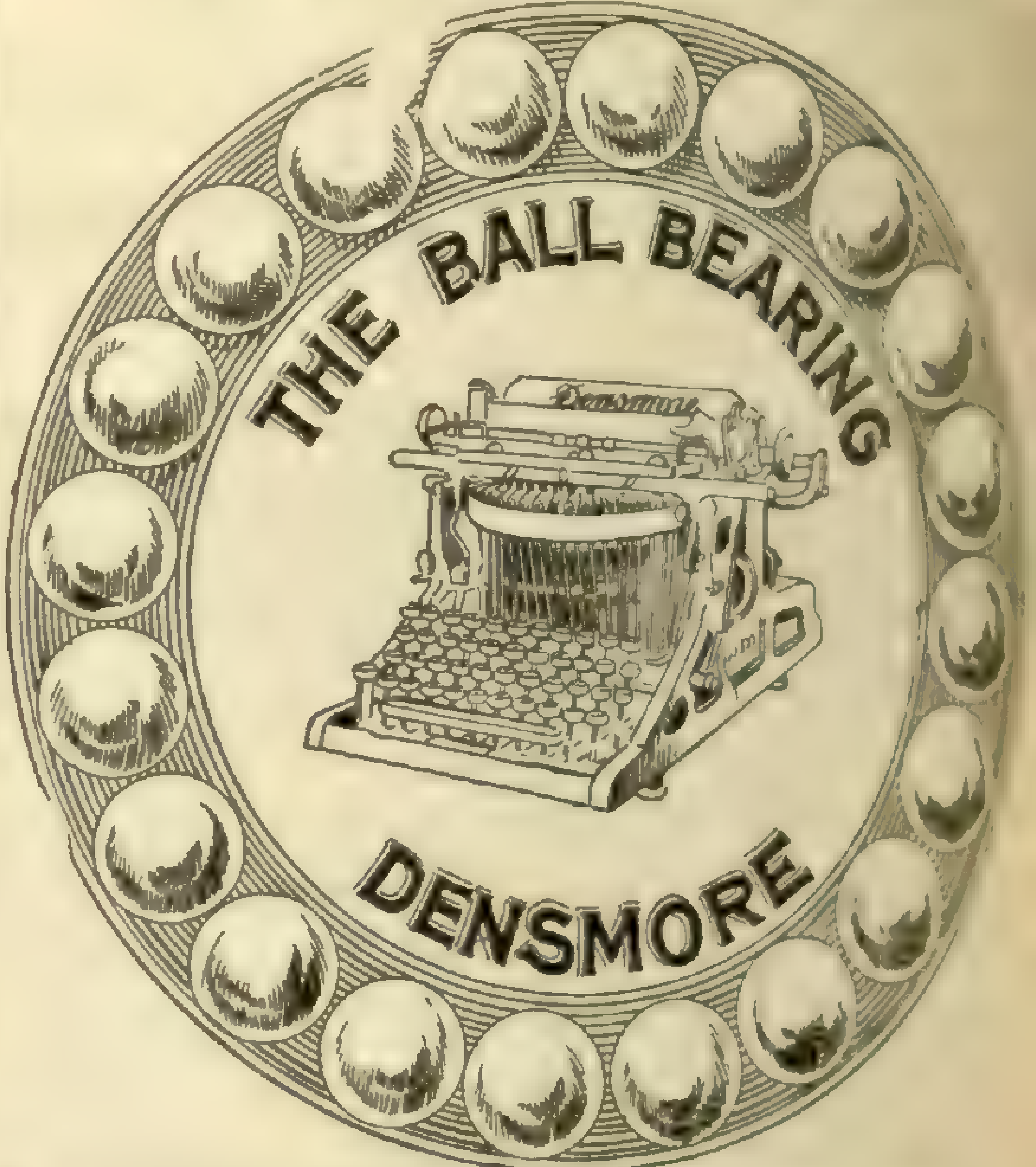

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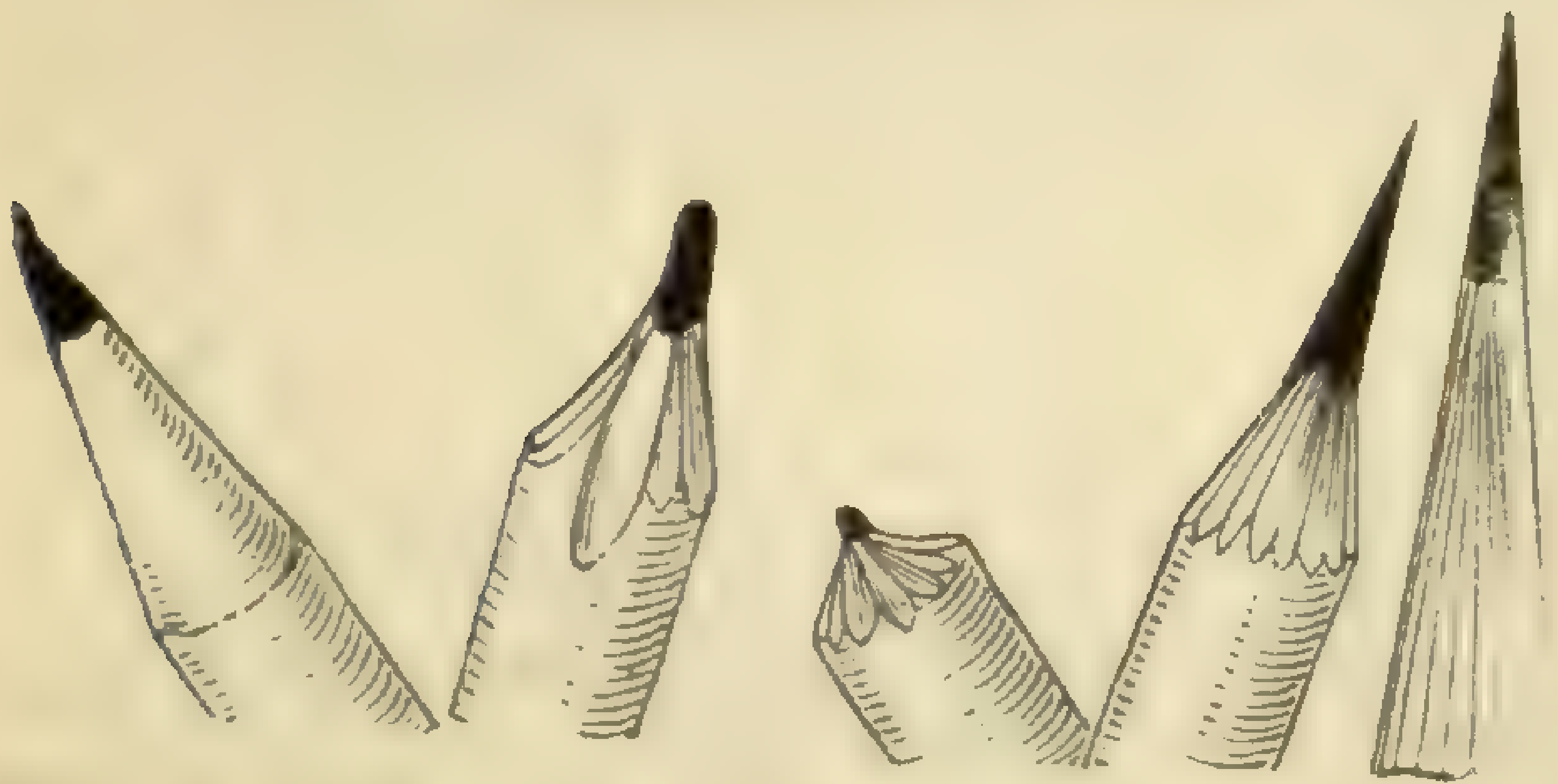

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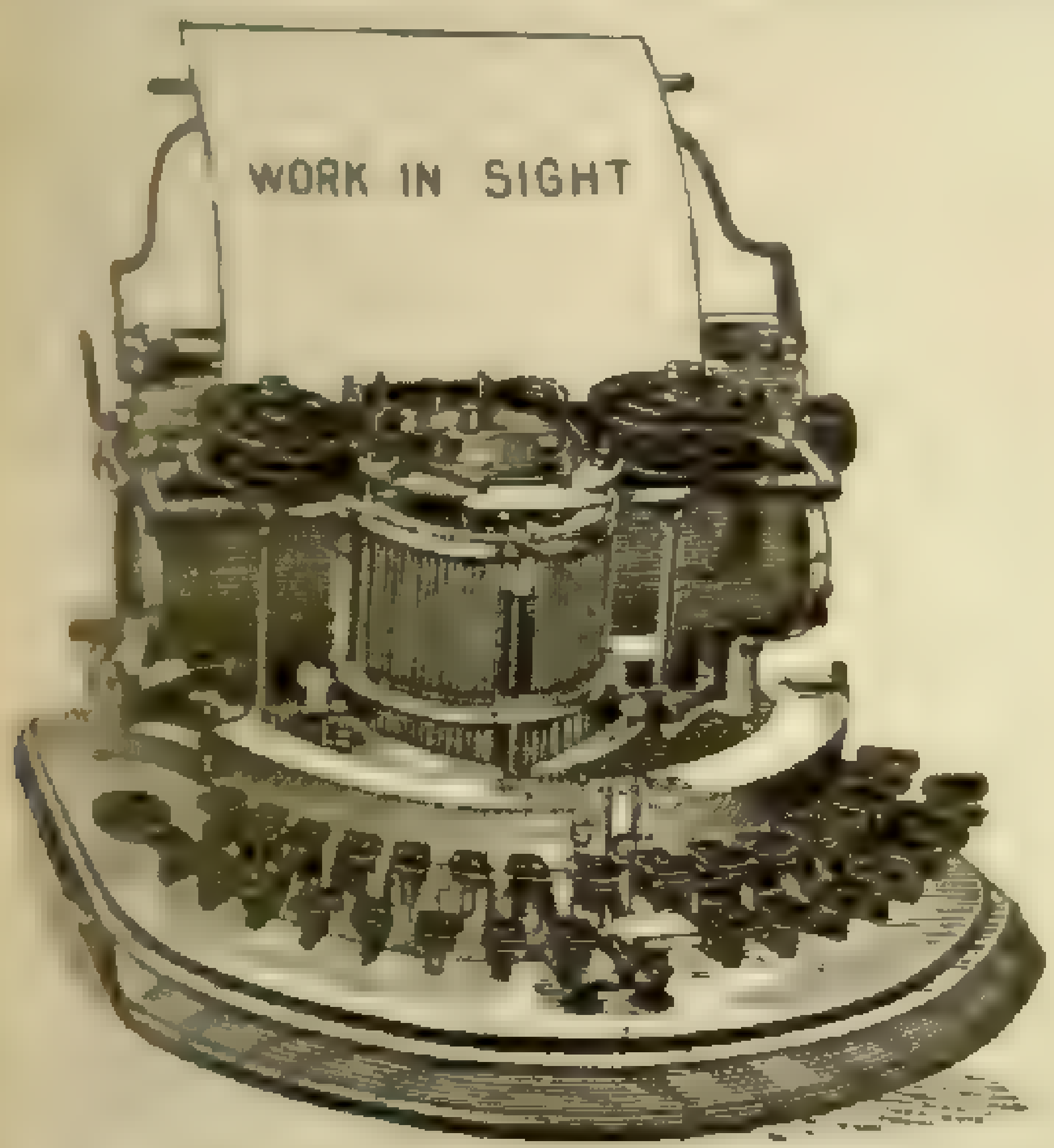
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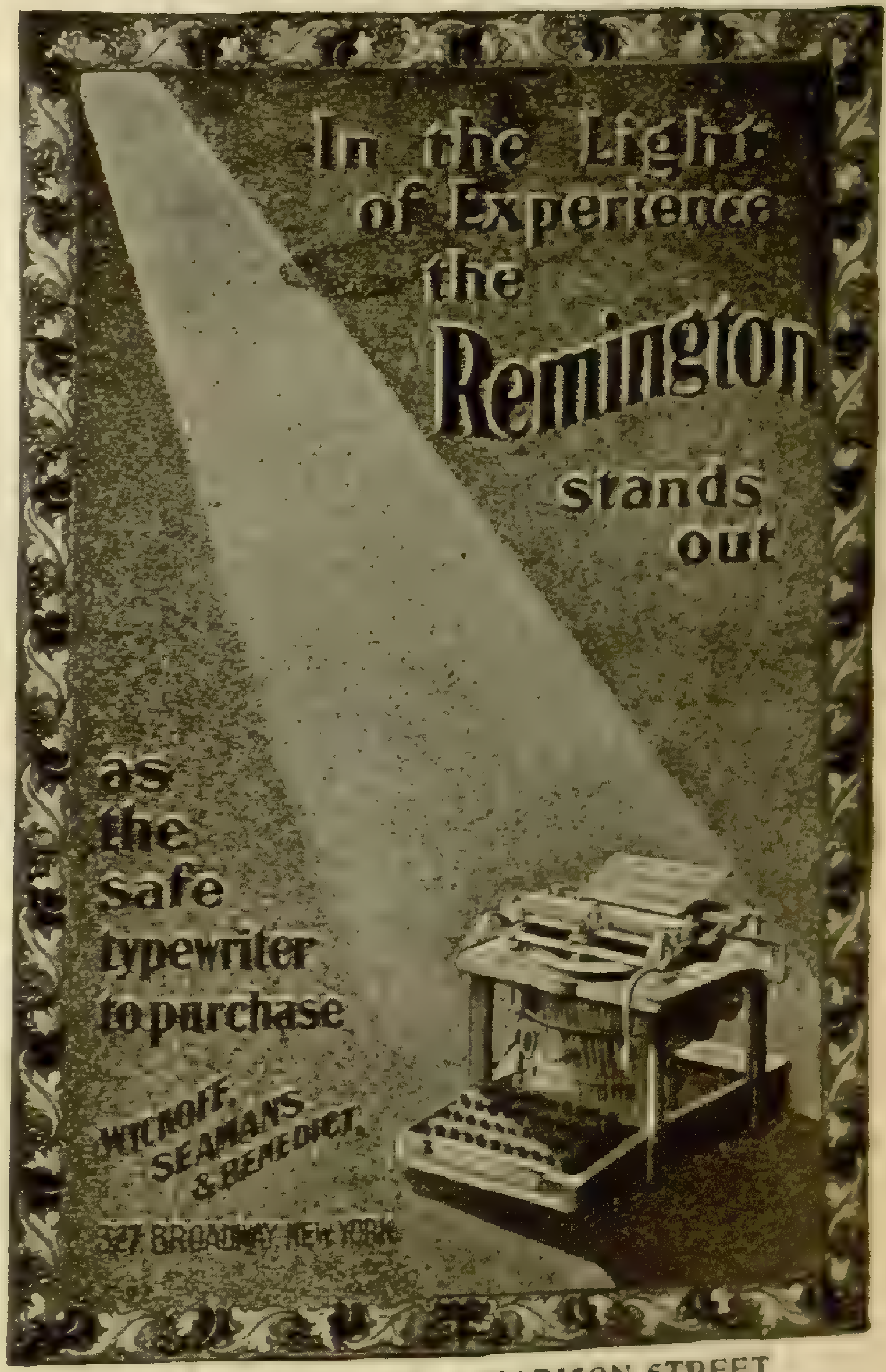
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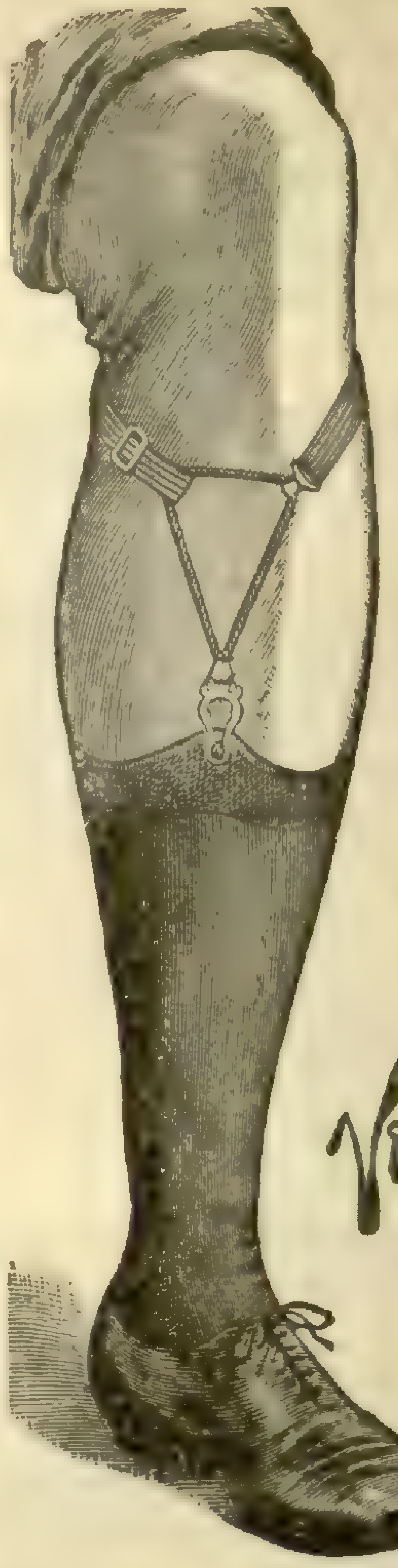

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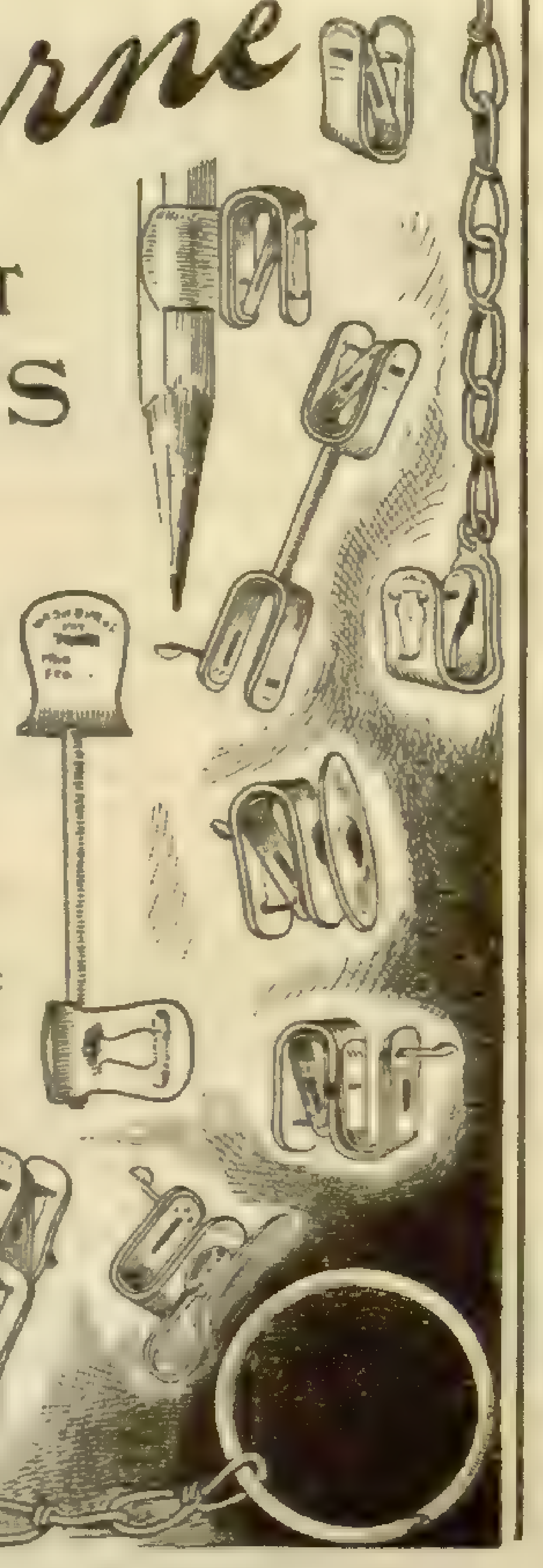

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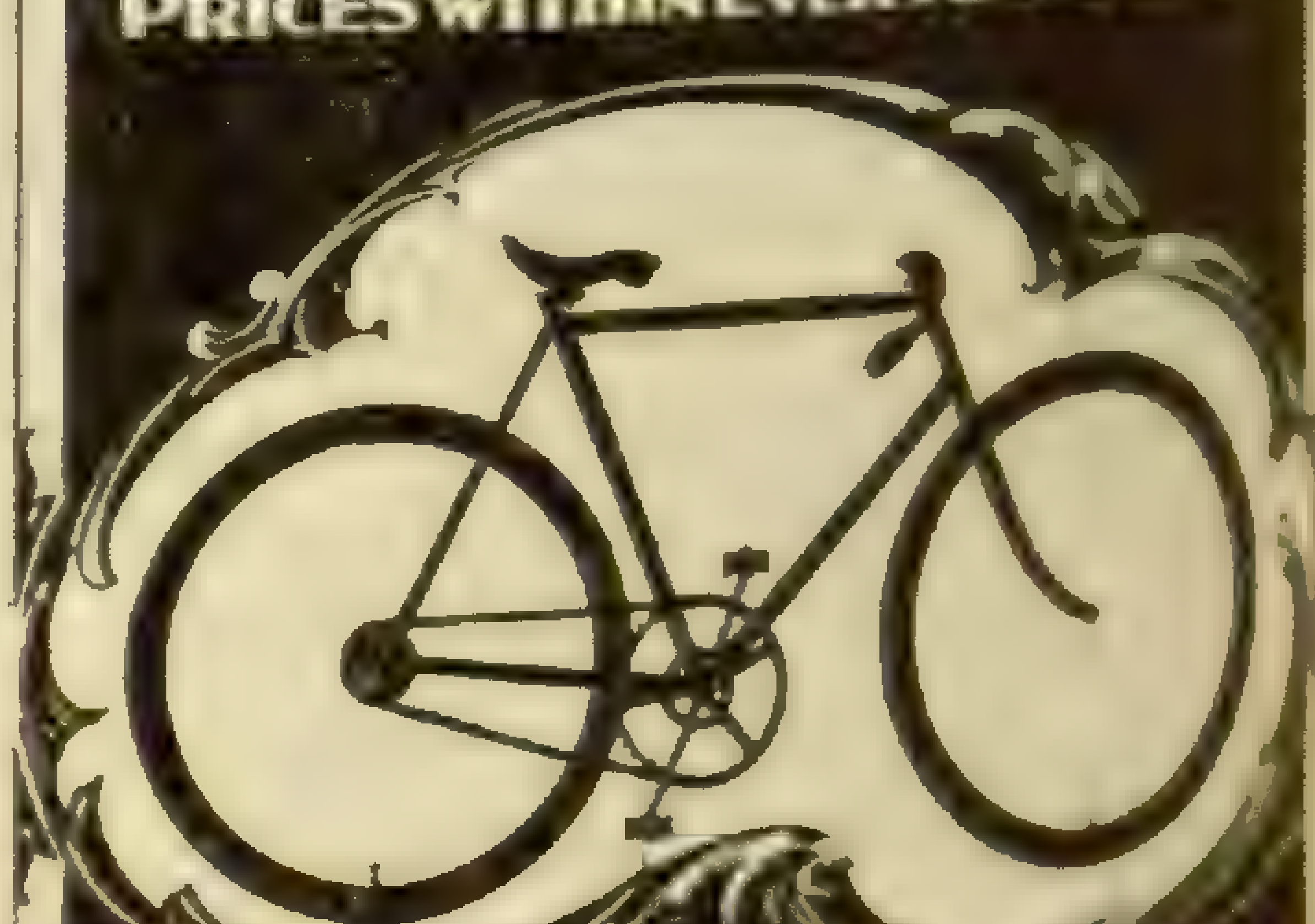

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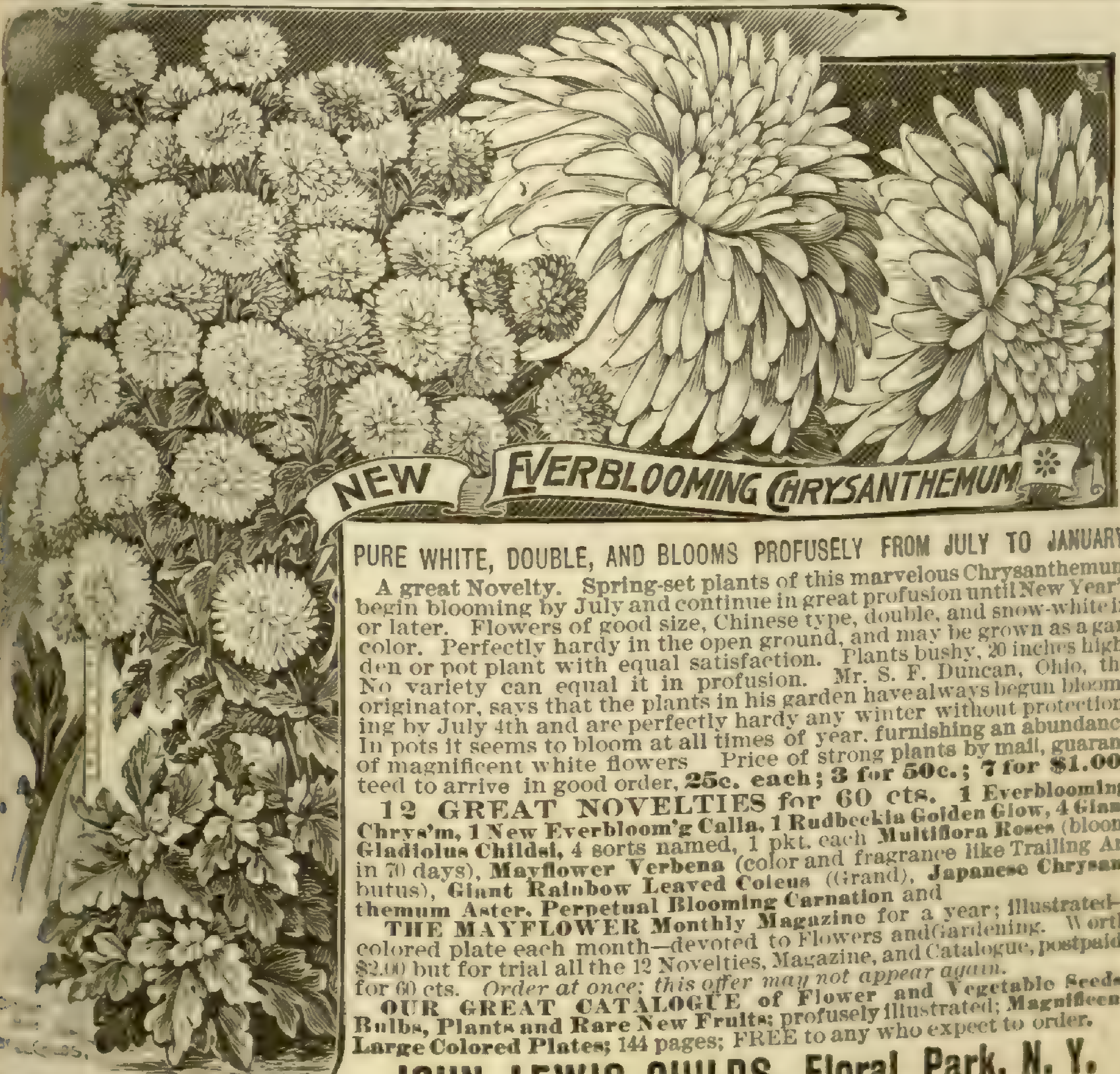

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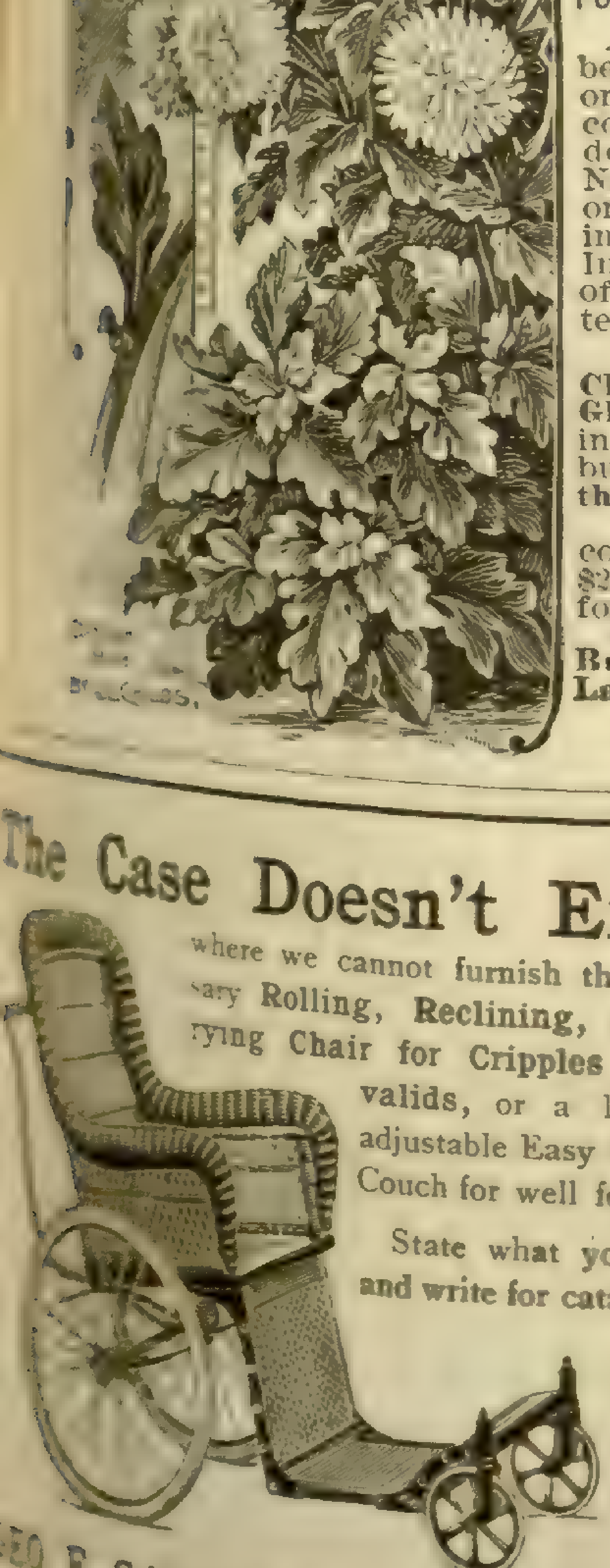

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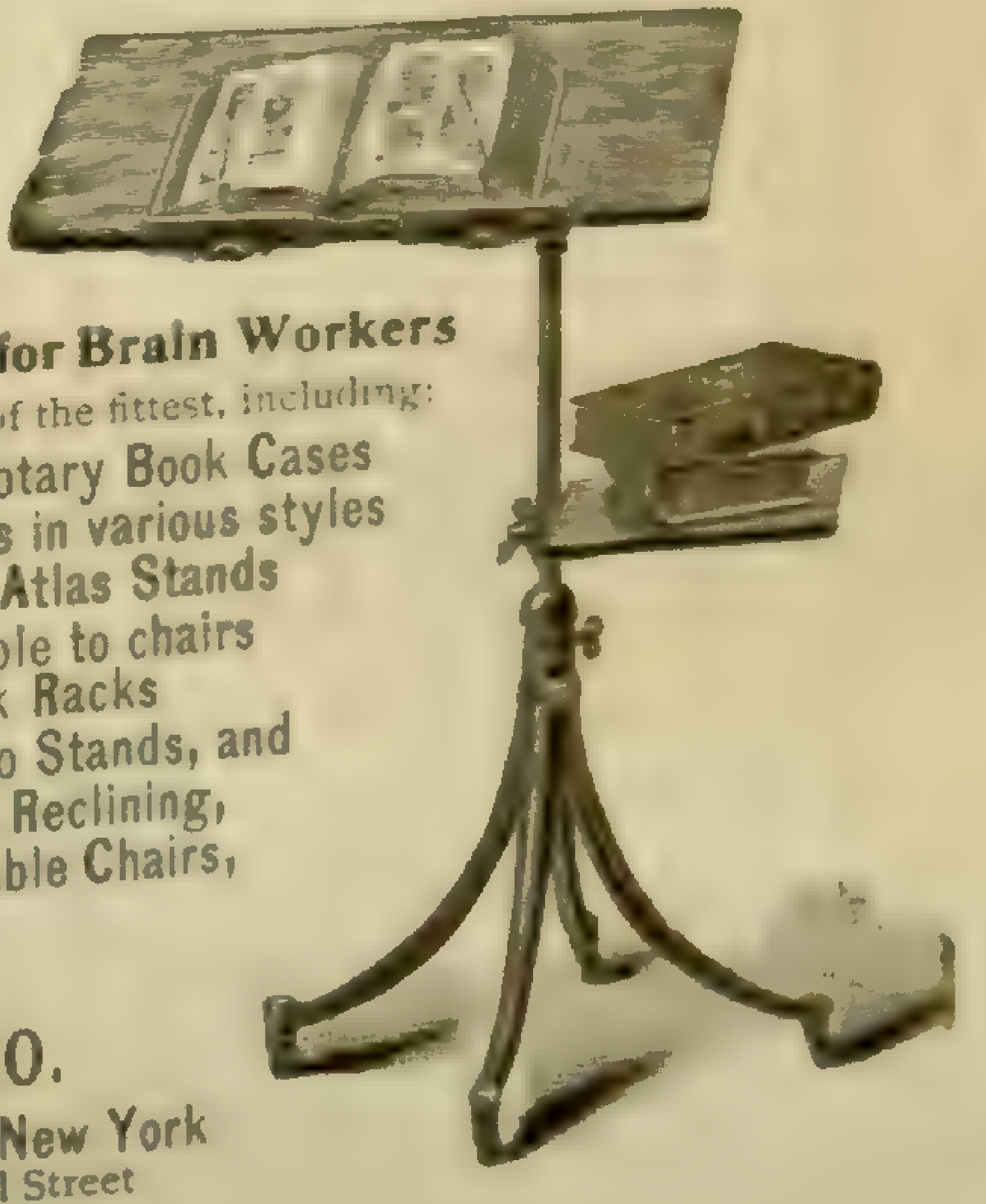

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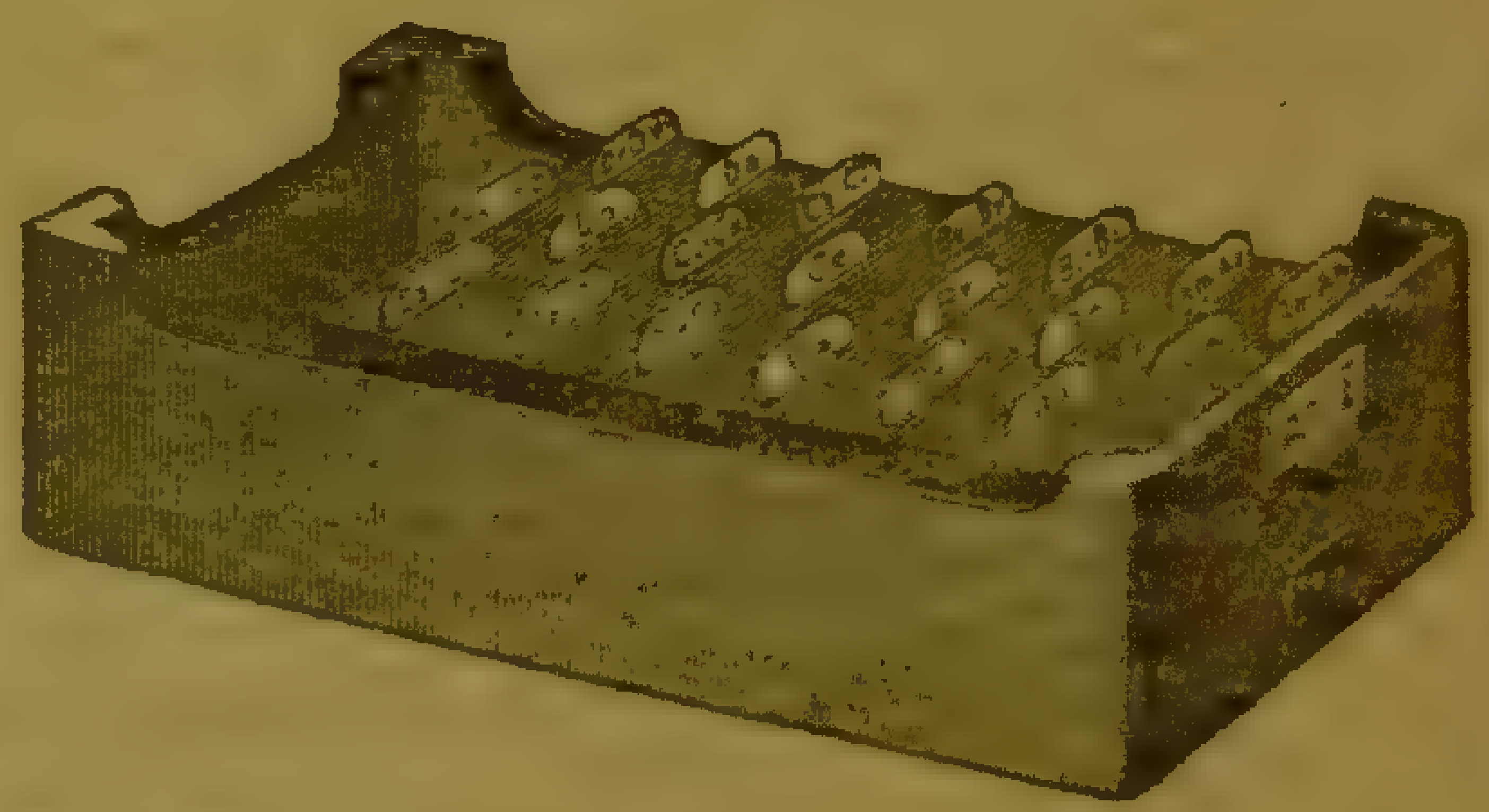

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Vol. XXVII MAY 1899 No. 5

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UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXI.[1]

JOHN DONNELL SMITH.

HAMPEA INTEGERRIMA Schlect., var. **appendiculata** Donn. Sm.—Folia ovato-lanceolata sursum sensim acuteque angustata juxta petiolum appendicibus duabus semiorbicularibus supra instructa.

Arbor 10^{m} alta, trunco diam. 3-decimetrali, coma globosa, floribus suaveolentibus.

In pascuis prope La Palma, Costarica, alt. 1550^{m}, Aug. 1898, *Tonduz*, n. 7379 Pl. Guat. etc., qu. ed. Donn. Sm. (n. 12462 herb. nat. Cost.).

Polyaster paucijugus Donn. Sm.—Folia magna quadrijuga, rachide nudo, foliolis petiolulatis discoloribus oblongo-lanceolatis acuminatis, lateralibus basi inaequali obtusis, terminali utrinque acuto. Panicula terminalis obpyramidata. Petala lineata. Filamenta glabra.

Ramuli cum paniculis flavo-velutini. Folia petiolo 8^{cm} longo adjecto [illegible] longa raro trijuga, foliolis 8-10^{cm} longis 3–3.5^{cm} latis epunctatis supra glabrescentibus subtus infra lanam flavam insigniter reticulatis, petiolis lateralibus 2–3^{mm} longis, terminali 1.6^{cm} longo. Panicula efoliata folia superiora aequans repetitus dichotoma, pedicellis quam flores brevioribus. Calycis [illegible] 2.5^{mm} lati dentes triangulares glabri. Petala 6^{mm} longa 2^{mm} lata, margine involuto, apice acuto inflexo. Torus obpyramidatus 1^{mm} altus glaber

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[1] Continued from BOT. GAZ. **25**: 157. 1898.

10-sulcatus. Stamina majora petala paene aequantia, cetera dimidio breviora, antheris orbicularibus. Ovarium subapocarpum, carpellis torum paulo superantibus totis cano-pilosissimis ima basi tantum coalitis ope stylorum sublateralium cohaerentibus collateraliter biovulatis. Fructus ignotus. Haec species a typo generis (*P. bromioide* Benth. et Hook., ad n. 874 Coulter's) cum in diagnosi tum foliis paniculisque decies majoribus distinctissima est.

Maxac, Depart. Huehuetenango, Guat., Jul. 1896, *Seler*, n. 3090.

BURSERA BIPINNATA Engl., var. **ovatifolia** Donn. Sm.—Rami novelli et floriferi cinereo-pilosi. Foliola supra pubescentia subtus tomentulosa ovata aut late ovalia, margine revoluto. Pedicelli fructiferi 4^{mm} longi. Drupae oblongo-ellipticae 8^{mm} longae stylo persistente apiculatae. An sit species nova?

Depart. Huehuetenango, Guat., alt. 1400^{m}, Jul. 1896, *Seler*, n. 3108.

Copaifera hemitomophylla Donn. Sm.—Foliola unijuga ad apicem petioli brevissimi sessilia dimidiata maxima lanceolato-oblonga acuminata basi exterius acutiuscula interius acute truncata glabra impunctata crebre nervia reticulato-venosa. Legumen magnum valde obliquum orbiculare turgidum, semine exarillato.

Arbor excelsa, coma globosa (Tonduz in schedulis), ramulis subflexuosis lenticellis punctatis. Petioli crassi corrugati $6-8^{\mathrm{mm}}$ longi, foliolis suberectis $11-15^{\mathrm{cm}}$ longis $4-4.5^{\mathrm{cm}}$ latis basi ad articulationem incrassatis. Pedunculus axillaris vix ullus aut usque ad 1^{cm} longus, pedicellis pauciaggregatis (in speciminibus suppetentibus 1-3-nis), $8-12^{\mathrm{mm}}$ longis, leguminibus breviter stipitatis $4-4.5^{\mathrm{cm}}$ longis $3.5-4^{\mathrm{cm}}$ latis $1.8-2.2^{\mathrm{cm}}$ crassis vix apiculatis fusco-furfuraceis. Flores deficiunt.—Haec a ceteris speciebus bifoliolatis Americanis, nempe *C. hymenaeifolia* Moric. et *C. confertiflora* Benth., foliolis magnis et oblongatis discrepat.

Santo Domingo de Golfo Dulce ad litora maritima, Cost., Mart. 1896. *Tonduz*, n. 7012 Pl. Guat., etc., qu. ed. Donn. Sm. (n. 9972 herb. nat. Cost.).

Myrcia Seleriana Donn. Sm. (*Aulomyrcia*, § CYMOSAE Berg. in Linnaea **27**: 71.)—Glabra. Folia coriacea subevenia utrinque impellucido-punctata lanceolata, apice obtuse acuminato, basi cuneata. Pedunculi axillares et terminales solitarii filiformes cymoso-triflori, flore intermedio sessili, lateralibus breviter pedicellatis. Calycis limbus utrinque tuberculatus usque ad medium lobatus, lobis 4 semiorbicularibus quam quintus orbicularis dimidio minoribus. Ovarium biloculare. Bacca abortu monosperma

Folia 4–5 cm longa 1.5 2 cm lata e medio utrinque angustata, costa subtus tum manifesta, nervis venisque subimmersis, punctis atris, petiolis 5 mm is. Pedunculi fructiferi 2.5–3.5 cm longi, pedicellis 5 mm longis bracteas sistentes lineares stipitatas aequantibus. Lobi calycini ciliati, minores alti. Antherarum loculus alterus altius affixus. Ovarium 4-ovulatum. ca globoso-ovalis 4 mm longa bracteolis dimidio brevioribus calyculata. ala in specimine suppetente deficiunt.—*Aulomyrciae subaveniae* Berg proxima, ut videtur.

Chaculá, Depart. Huehuetenango, Guat., alt. 1600 m, Jun. 1896, *Seler*, n. 3169.

Eugenia pachychlamys Donn. Sm. (§ GLOMERATAE Berg l. c. 183.)—Rufo-tomentosa. Folia primo utrinque tomentosa deinde raeter costam glabrescentia et supra lucida obovato-elliptica aut iptica in acumen obtusum producta deorsum cuneata longiscule petiolata. Flores axillares et subterminales subglomerati auci majusculi petiolos aequantes, pedunculo pedicellisque vix is. Calyx crassus, segmentis utrinque tomentosis aequalibus.

Frutex 2–3 m altus (Heyde et Lux in schedulis). Folia disticha coriacea ucido-punctata 7.5–9.5 cm longa 3.5–5 cm lata, petiolis 1.5 cm longis sicut uli tomentosis. Pedunculus solitarius 1–3 mm longus cum pedicellis 3–4 mm is crassus et tomentosus, floribus 2–4 centripetim evolutis 4-meris diatro 2.5-centimetralibus, bracteolis crassis oblongis 5 mm longis, alabastris rtis obovatis 1 cm longis. Calycis supra ovarium haud producti tubus yramidatus 3 mm altus, segmenta ovata 6 mm longa. Petala praeter mares glabra oblongo-elliptica 1 cm longa genitalibus paulo longiora. Antherae ovales 1 mm longae glandula apiculatae prope basin affixae. Discus pilosellus atus. Ovarii locula 2 multiovulata, stylo sparsim piloso. Baccae unt.

Fraijanes, Depart. Amatitlan, Guat., alt. 1200 m, Apr. 1892, *Heyde et Lux*, n. 3961 Pl. Guat., etc., qu. ed. Donn. Sm.—Cerro Gordo, Depart. Santa Rosa, Guat., alt. 1100 m, Dec. 1892, *Heyde et Lux*, n. 4179 Pl. Guat., etc., qu. ed. Donn. Sm.

Eugenia Salamensis Donn. Sm. (§ CORYMBIFLORAE Berg l. c. 26.)—Exceptis foliis vetustioribus ferrugineo-velutina. Haec coloria oblongo-aut obovato-elliptica apice obtusata aut breime obtuseque acuminata basi rotundata aut retusa. Corymbi illares foliis dimidio breviores obpyramidati. Calyx usque ad cum partitus, segmentis utrinque velutinis oblongo-ovatis, ternis paulo majoribus acutioribusque.

Folia nascentia sicut ramuli petioli corymbi calyces ferrugineo-velutina, aetate provectiore supra nitentia subtus cinereo-pubescentia 11–12^{cm} longa 4–6^{cm} lata membranacea pellucido-punctata, petiolis 7–9^{mm} longis. Inflorescentia centripeta, corymbis ad axillas oppositas solitariis, axibus oppositis, pedicellis quam flores brevioribus bracteolas subulatas 5–7^{mm} longas subaequantibus. Calycis segmenta 5–6^{mm} longa. Petala extus pilosella obovata 7^{mm} longa genitalibus paulo breviora. Discus diam. 5-millemetralis praeter basin styli glaber. Ovarium parvum obpyramidatum biloculare, ovulis in utroque loculo circiter 12. Fructus ignotus.

Depart. Salamá, Guat., Dec. 1896, *Seler*, n. 2445.

Conostegia tenuifolia Donn. Sm.—Ramuli novelli cum petiolis et cyma stellato-puberuli. Folia glabra tenuiter membranacea majuscula disparia oblongo-obovata aut-elliptica in caudam tenuem acuminata basi acuta integra quintuplinervia. Cyma subcorymbiformis multiflora, alabastris ovoideis basi subtruncatis mucrunculo apiculatis. Petala 4–6 obdeltoidea valde inaequilatera emarginata. Stamina 16–22. Ovarium 10–12-loculare.

Folia pellucida in eodem jugo alterum 1.3–2^{dm} longum 5–7^{cm} latum, alterum magis obovatum 9–12^{cm} longum 3.5–5.5^{cm} latum, petiolis 0.5–3^{cm} longis. Cyma 4–6^{cm} alta, pedicellis 3–5^{mm} longis, alabastris pube stellata punctatis mucrunculo 1^{mm} longo adjecto 8–9^{mm} longis 4^{mm} crassis. Petala saepius flava 8^{mm} longa atque lata. Antherae plerumque 20 oblongae 2^{mm} longae, filamentis 3^{mm} longis. Stylus crassiusculus 7^{mm} longus, stigmate capitato.—Juxta *C. puberulam* Cogn. et *C. Poeppigii* Cogn. locanda.

In sylvis prope Shirores, Talamanca, Cost., alt. 100^{m}, Febr. 1895, *Tonduz*, n. 9339 herb. nat. Cost.—Rio Pacuare, Llanuras de Santa Clara, Cost., alt. 150^{m}, Apr. 1896, *Donn. Sm.*, n. 6571 Pl. Guat. etc., qu. ed. Donn. Sm.—Rio Verde, Llanuras de Santa Clara, Cost., alt. 250^{m}, Maj. 1896, *Donn. Sm.*, n. 6574 Pl. Guat. etc., qu. ed. Donn. Sm.

Tococa parvifolia Donn. Sm. (§ ANAPHYSCA Benth. in Hook. Journ. Bot. 2: 305).—Exceptis foliis glaberrima. Haec primo stellato-furfuracea denique praeter axillas subtus nervorum glabrescentia longiuscule petiolata e basi rotunda aut retusa lanceolata sensim acuteque angustata quintuplinervia supra medium mucro-serrulata. Cyma folia superans, ramis simplicibus trifloris, floribus 5–7-meris. Calycis limbus sinuato-lobatus dentibus filiformibus appendiculatus. Ovarium 3-loculare annulo crenato coronatum.

Suffrutex 1^{m} altus ramosus, ramis sicut cymarum axes purpureis nitenti- s. Folia coriacea 5–8^{cm} longa 1.5–2.5^{cm} lata supra purpureo-maculata, basi duplicata interdum supra biglandulari, nervis interioribus purpureis quam eriores multo longioribus validioribusque, petiolis canaliculatis 1.5–2^{cm} gis. Cymae ramulos terminantes corymbiformes 6–9^{cm} altae ebracteolatae, icello intermedio vix ullo, lateralibus 1.5–2^{cm} longis, floribus saepius meris 1.5–1.7^{cm} longis. Calycis tubus primo obconicus denique urceolatus altus intus 10-costatus, dentes exteriores 4–5^{mm} longi. Petala oblongo- vata 10–12^{mm} longa. Antherae 7–8^{mm} longae filamenta decurva aequan- s valde incurvae, connectivo basi postice subbigibboso. Ovarium ovoideum altum ultra medium liberum, sulcatum apice intrusum, stylo glabro 14^{mm} longo, stigmate punctiformi. Baccae non visae.

Santa Rosa, Depart. S. Rosa, Guat., alt. 600^{m}, Sept. 1893, *Heyde et Lux*, n. 6137 Pl. Guat. etc., qu. ed. Donn. Sm.

Henriettella tuberculosa Donn. Sm. (§ EUHENRIETTELLA Tri- nı.—Folia scabrida supra tuberculata subtus foveolata ad rvos venasque strigosa in eodem jugo plus minus inaequimagna ongo-obovata aut-elliptica longe acuteque cuspidato-acumi- ta in petiolum angustata integra 5-plinervia. Pedicelli brevis- mi basi pluribracteosi, floribus 5-meris inter minimos. Calyx presse paleaceo-strigosus. Petala obovata. Stylus elongatus.

Ramuli teretes scabridi, internodiis 1–1.5^{cm} longis. Folia subcoriacea longa 2–3.3^{cm} lata, venis transversis rectis subtus tantum manifestis, is 0.5–1^{cm} longis. Pedicelli 5–8-fasciculati 1^{mm} longi bracteas aequan- s. Calyx 2^{mm} altus, limbo haud constricto vix dilatato minutissime denticu- dentibus exterioribus acuminatis. Petala 2^{mm} longa obtusa. Filamenta urva 2^{mm} longa, antheris 1^{mm} longis. Stylus 6^{mm} longus, stigmate capitel- .—*H. verrucosae* Triana proxima, ut videtur.

Talamanca, Cost., Apr. 1895, *Tonduz*, n. 7263 Pl. Guat. etc., qu. ed. n. Sm. (n. 9906 herb. nat. Cost.)

Rondeletia Hondurensis Donn. Sm.—Stipulae e basi late ovata 3-setaceae. Folia subsessilia discoloria subtus niveo-arach- dea oblongo-elliptica utrinque acuminata. Cyma terminalis sessilis primo capitiformis denique confertim corymbiformis, acteis stipuliformibus, floribus sessilibus maximis 5-meris cano- osis. Calycis segmenta linearia tubo longiora. Corollae bus intus glaber, os haud constrictum nudum, lobi obovati erne intus villosi.

Arbuscula, ramulis cymis floribus dense longeque villosis. Stipulae 1^{cm} longae basi 6^{mm} latae, setis 5^{mm} longis. Folia supra pubescentia utrinque ad nervos ferruginea $11–16^{cm}$ longa $3.5–5.5^{cm}$ lata, petiolis $2–4^{mm}$ longis. Cymae axes $4–10^{mm}$ longae, bracteae 1.5^{cm} longae, flores circiter 3–5-capitati. Calycis tubus obovatus $5–6^{mm}$ altus, lobi non satis aequales $10–14^{mm}$ longi acuti. Corollae tubus $2–2.5^{cm}$ longus, lobi 1^{cm} longi. Antherae 3^{mm} longae. Ovarium 2^{mm} altum, styli lobis exsertis ovatis 1.5^{mm} longis. Capsula ignota.— *R. dubiae* Hemsl. proxima.

Rio Chamelecon, Depart. Santa Bárbara, Honduras, alt. 300^{m}, Dec. 1888, *Thieme*, n. 5267 Pl. Guat. etc., qu. ed. Donn. Sm.

Gonzalea ovatifolia Donn. Sm.— Ramuli sicut spicae floresque appresse pilosi. Folia praeter nervos subtus pilosos glabra maxima ovata longe acuminata basi rotunda, petiolis brevissimis. Flores subspicati 4-meri bracteas aequantes. Calycis lobi inaequales. Corolla infundibuliformis ovario 3–4-plo longior ad ⅓ longitudinis staminigera. Antherae sessiles basifixae. Bacca 4-pyrena, seminibus numerosissimis.

Frutex $3–4^{m}$ altus, ramulis ferrugineis. Stipulae e basi deltoidea $7–10^{mm}$ longae. Folia $1–1.5^{dm}$ longa $5.5–8.5^{cm}$ lata, basi nonnunquam inaequilatera et subacuta, petiolis $2–4^{mm}$ longis. Spicae $2–4.5^{dm}$ longae, bracteis sicut bracteolae dimidio breviores filiformibus, floribus pauciaggregatis. Calycis tubus 1.5^{mm} altus, lobi 3 ovati 1^{mm} longi quam quartus oblongus dimidio breviores. Corolla alba $5–6^{mm}$ longa ad duas partes superiores intus niveo-arachnoidea, lobis non satis aequalibus ovatis 1.5^{mm} fere longis obtusis prope basin intus pubescentibus. Antherae oblongae 1^{mm} longae. Ovarium 4-loculare. Bacca alba succosa globosa 4-sulcata pubescens diametro 5-millimetralis pyrenis osseis, seminibus pro pyrena circiter 35 atro-nitidis scrobiculatis.

Atirro, Prov. Cartago, Cost., alt. 600^{m}, Apr. 1896, *Donn. Sm.*, n. 6599 Pl. Guat. etc., qu. ed. Donn. Sm.— Rio Pacuare, Llanuras de Santa Clara, Cost., alt. 150^{m}, Apr. 1896, *Donn. Sm.*, n. 6600 Pl. Guat. etc., qu. ed. Donn. Sm.— Shirores, Talamanca, Cost., alt. 100^{m}, Febr. 1895, *Pittier et Tonduz*, n. 9171 herb. nat. Cost.— Eandem plantam legit *Hart* prope La Laguna de Chiriqui Panamá, 1895, n. 113.

Hoffmannia tetrastigma Donn. Sm.— Ferruginea. Folia tenuiter membranacea supra tuberculato-asperula subtus praesertim ad nervos molliter pubescentia oblongo-elliptica acuminata in petiolum attenuata. Cymae fasciculatae pedunculatae petiolos superantes, floribus indefinitis. Calycis dentes triangulares orollae lobi quam tubus dimidio fere breviores. Ovarium 4-loculare, stigmatibus 4 oblongis.

Stipulae triangulares. Folia integra petiolo 4-5^{cm} longo adjecto 28-35^{cm} nga 8.5-10^{cm} lata, costa subtus complanata 3^{mm} lata, nervis lateralibus rinsecus 14-15 juxta marginem anastomosantibus. Cymae pubescentes -fasciculatae 6-9^{cm} longae, pedunculis 2-4^{cm} longis, bracteis ovatis 1^{cm} ngis, floribus pubescentibus 4-meris numerosissimis. Calyx obovatus esul-atus 3^{mm} altus pedicellum subaequans. Corolla 11-14^{mm} longa, lobis longo-triangularibus 4-5^{mm} longis. Antherae obtusae 4^{mm} longae 1^{mm} latae. varium vertice liberum multiovulatum, stylo corollam aequante, stigmatibus 2^{mm} longis. Baccae ignotae.

In sylvis humidis tenebrosis prope Zamorora, Depart. Santa Rosa, Guat., lt. 1800^{m}, Apr. 1893, *Heyde et Lux*, n. 4490 Pl. Guat. etc., qu. ed. Donn. Sm.

Psychotria Suerrensis Donn. Sm.—Stipulae utrinque binae remotae setoso-lineares. Folia brevissime petiolata oblongo-lliptica longe acuminata basi acuta aut acuminata glaberrima. Cyma pedunculata glomeroso-contracta 4-ramea latior quam longior tota pubescens, bracteis foliaceis coloratis ab axillis remo-tis 1-3-nis ramos superantibus, floribus 1-4-aggregatis sessilibus bracteas subaequantibus. Calyx truncatus vix denticulatus.

Frutex orgyalis et ultra. Stipulae 4-5^{mm} longae in vaginam connatae. lia pellucida, nascentia erubescentia, vetustiora 12-22^{cm} longa 4-9.5^{cm} ta, costa cum nervis lateralibus utrinsecus 9-11 valida et rubra, venis con-cuis, petiolis 5-7^{mm} longis. Pedunculus terminalis nonnunquam ex axillis premis etiam ortus 1-3^{cm} longus. Cyma 2.5-4^{cm} lata, fructifera aucta, brac-is plerumque terminalibus et ternis pubescentibus primo erubescentibus demque violaceis oblongo-ellipticis 1-1.5^{cm} longis, fructiferis latioribus et 2^{cm} ngis, floribus saepius 3-capitatis 4-5-meris pubescentibus in sicc. totis eru-scentibus. Calycis pars superior ovario longior discum globosum aequans. rolla (vivens) alba 12^{mm} longa, tubo lobis intus glabris 3-plo longiore supra lum intus pubescente ad $\frac{2}{3}$ longitudinis staminigero. Antherae subses-es paulo infra mediam affixae lineares 3^{mm} longae inclusae. Stylus corol-m aequans, lobis oblongis 2^{mm} longis. Drupa globosa diam. 4-millemetralis acea pubescens 2-pyrena, seminibus dorso leviter sulcatis, albumine meo.—Cum *P. contracta* Muell. Arg. collocare debetur.

In sylvis profundis Suerrensibus, Llanuras de Santa Clara, Cost., alt. , Febr. et Apr. 1896, *Donn. Sm.*, n. 6580 Pl. Guat. etc., qu. ed. Donn. m.—Eandem plantam invenit *Tonduz* prope Tsuritkub, Talamanca, Cost., art. 1894, n. 8683 herb. nat. Cost.

Lobelia fasciculata Donn. Sm. (§ Holopogon Benth et Hook.) —Caulis decumbens foliis decurrentibus angulatus. Haec sessilia parva internodis longiora elliptica aut lanceolata evenia crenato-serrata. Pedunculi graciles, pedicellis paucis subumbellatim fasciculatis calyce longioribus. Calycis tubus oblique hemisphericus laciniis paulo brevior. Corollae unilabiatae tubus basi obliquus calyce aequilongus, lobi spathulato-obovati apice cuspidati, inferiores ceteris paulo majores quam tubus dimidio longiores. Antherae inclusae.

Glabrescens. Caulis 7–15^{cm} longus. Folia opaca supra pubescentia, inferiora 8^{mm} longa 4^{mm} lata, superiora 14^{mm} longa 4^{mm} lata. Pedunculi 2–3 circiter 5^{cm} longi. Inflorescentia cum calycibus pubescens. Pedicelli plerumque 5 circiter 5–8^{mm} longi bracteas lineari-lanceolatas serrulatas aequantes. Calycis tubus 3^{mm} altus, laciniae subulatae 4^{mm} longae serrulatae. Corollae lobi superiores 6^{mm} longi, inferiores 7^{mm} longi. Staminum tubus subliber, antheris 1^{mm} longis, omnibus vertice barbatis. Capsulae desunt.— Species alpina lobis corollinis insignis.

Todos Los Santos, Depart. Huehuetenango, Guat., alt. 3000^{m}, Sept. 1896. *Seler*, n. 3022.

Lobelia stolonifera Donn. Sm. (§ Hemipogon Benth et Hook.) —Glabra. Folia radicalia conferta petiolata spathulato-oblanceolata, caulina pauca prope basin sita amplexicaulia lineari-lanceolata. Caulis scapiformis ad apicem versus racemoso-pauciflorus. Corollae tubus lacinias calycinas vix aequans lobis propriis superioribus linearibus paulo brevior inferioribus obovatis dimidio brevior. Antherae minores setula unica appendiculatae.

Caulis assurgens 10–14^{cm} longus. Folia obscure dentata, radicalia petiolo adjecto 4–6^{cm} longa, caulina 1–2 circiter 2–3, 5^{cm} longa. Stolones filiformes 12–17^{cm} longi, foliis spathulato-obovatis sparsis ad apicem radicantem rosulatis. Racemus 3–4-florus, pedicello infimo 1–1, 5^{cm} longo bracteam foliaceam ciliatam aequante, pedicellis superioribus a bracteis superatis. Calycis tubus pubescens obovatus 3^{mm} altus, laciniae subulatae 5^{mm} longae. Corolla coerulea (cl. Seler in schedula), lobis inferioribus 8^{mm} longis. Staminum tubus liber, antheris subglabris subexsertis, majoribus 2^{mm} longis et vertice nudis. Capsulae non suppetunt.

Todos Los Santos, Chiantla, Depart. Huehuetenango, Guat., alt. 3000^{m}, Sept. 1896, *Seler*, 3017.

Macleania Turrialbana Donn. Sm.— Folia nascentia glandu- ri-punctata supra cum ramulis novellis pilosella, vetustiora labra elliptica utrinque acuta aut obtusiuscula penninervia petio- li. Racemi folia superantes secundiflori, pedicellis supra basin bracteatam articulatis et bibracteolatis. Calycis tubus teres. rolla glabra staminibus bis paene longior. Antherae tubum aequantes.

Epiphyticus. Folia crasse coriacea 4–6$^{\text{cm}}$ longa 2–3.5$^{\text{cm}}$ lata, margine so. nervis lateralibus utrinsecus 4–5, petiolis corrugatis 4–9$^{\text{mm}}$ longis. cemi ex axillis superioribus orti 8–14-flori, fructiferi elongati et decurvi, teis bracteolisque semiorbicularibus acuminatis 2–2.5$^{\text{mm}}$ longis margine rulis, pedicellis crassis 12–18$^{\text{mm}}$ longis ad $\frac{1}{3}$–$\frac{1}{5}$ longitudinis articulatis, bus 5-meris. Calycis tubus campaniformis 5$^{\text{mm}}$ altus, limbus patens 3$^{\text{mm}}$ s sinuato-dentatus. Corolla rosea succosa cylindracea subpentagona ad am partem ampliata, lobis deltoideis 2$^{\text{mm}}$ longis. Filamenta leviter erentia 3$^{\text{mm}}$ longa complanata, antheris paulo infra medium affixis tubo to 10$^{\text{mm}}$ longis. Discus annularis. Bacca globoso diam. 7-milleme- s vertice depressa, loculis 5 polyspermis, seminibus obovoideis.— Ab bus praeter *M. cordifoliam* Benth. speciebus adhuc cognitis inflorescentia racemosa differt.

Volcan de Turrialba, Cost., alt. 2600$^{\text{m}}$, Jan. 1899, *Pittier*, n. 7546 Pl. at., etc., qu. ed. Donn. Sm. (n. 13.090 herb. nat. Cost.).

BALTIMORE, Md.

(*To be concluded.*)

A CONSPECTUS OF THE GENUS LILIUM.

F. A. WAUGH.

(WITH FIGURES 1–14)

[*Concluded from p. 254.*]

28. L. OXYPETALUM Baker, Linn. Soc. Jour. **14**: 234. 1874.
Fritillaria oxypetala Royle, Ill. Bot. Him. **1**. 388?. 1839.

Bulb oblong, with few lanceolate acuminate scales: stem slender, 3–4.5^{dm} tall: leaves 20–30, scattered, ascending, lanceolate or linear: perianth horizontal, wide funnel-shaped, 2.5–4^{cm} long, with oblong, acute segments, purplish tinged beneath with green, and dotted on the inner half of the upper surface, thickly papillose toward the center: stamens less than one third the length of the perianth; anthers purplish; filaments divergent: ovary clavate; style straight, shorter than the ovary.

Western Himalayas.

29. L. PAPILLIFERUM Franchet, Jour. Bot. **6**: 316. 1892.

Bulb small subglobose, with 10–12 thick ovate scales, closely imbricated: stem nearly 3^{dm} in height, densely clothed with short hairs, leafless for a considerable distance at the base: leaves scattered, the lower oblong-obtuse, the upper only half as large, linear, acute, all of them about 5-nerved, scabrous along nerves and margins: flowers one or two, nodding at the beginning of the summer, and becoming horizontal; perianth small, 5–6^{cm}, dirty red, short tubular at the lower part, with the segments subrevolute: filaments divergent, with anthers yellow: style a little longer than the ovary.

Yun-nan, China.

30. L. HENRYI Baker, Gard. Chron. III. **4**: 660. 1888.

Bulb globose, 5^{cm} in diam., outer scales ovate, fleshy: stem 6–10^{dm} long below the inflorescence: leaves subsessile, spreading, continued up to the very top; fully developed leaves lanceolate

20 long, upper gradually smaller, uppermost ovate: inflo-scence a lax corymb of 4–8 flowers, bracteate at base by a whorl of small ovate leaves: perianth yellow, 7.5–9^{cm} long; segments lanceolate, subobtuse, spreading from the middle, marked in the lower half with a few irregularly scattered brown spots: stamens equal the perianth segments; anthers linear: ovary subcylindric, 2.5^{cm} long; capsule oblong, obtusely angled.

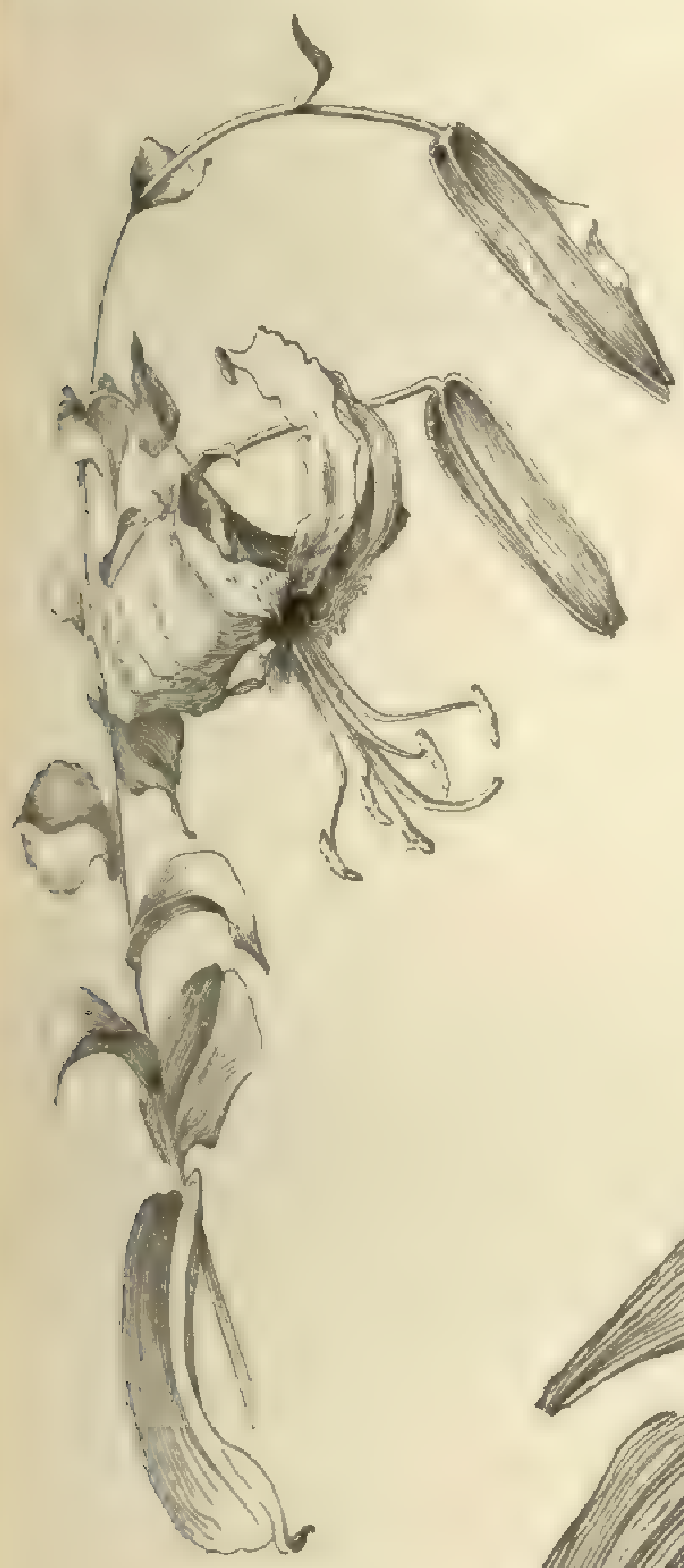

Fig. 6.—Lilium Henryi.

Ichang, western China. Just coming into cultivation. Extremely thrifty and fine.

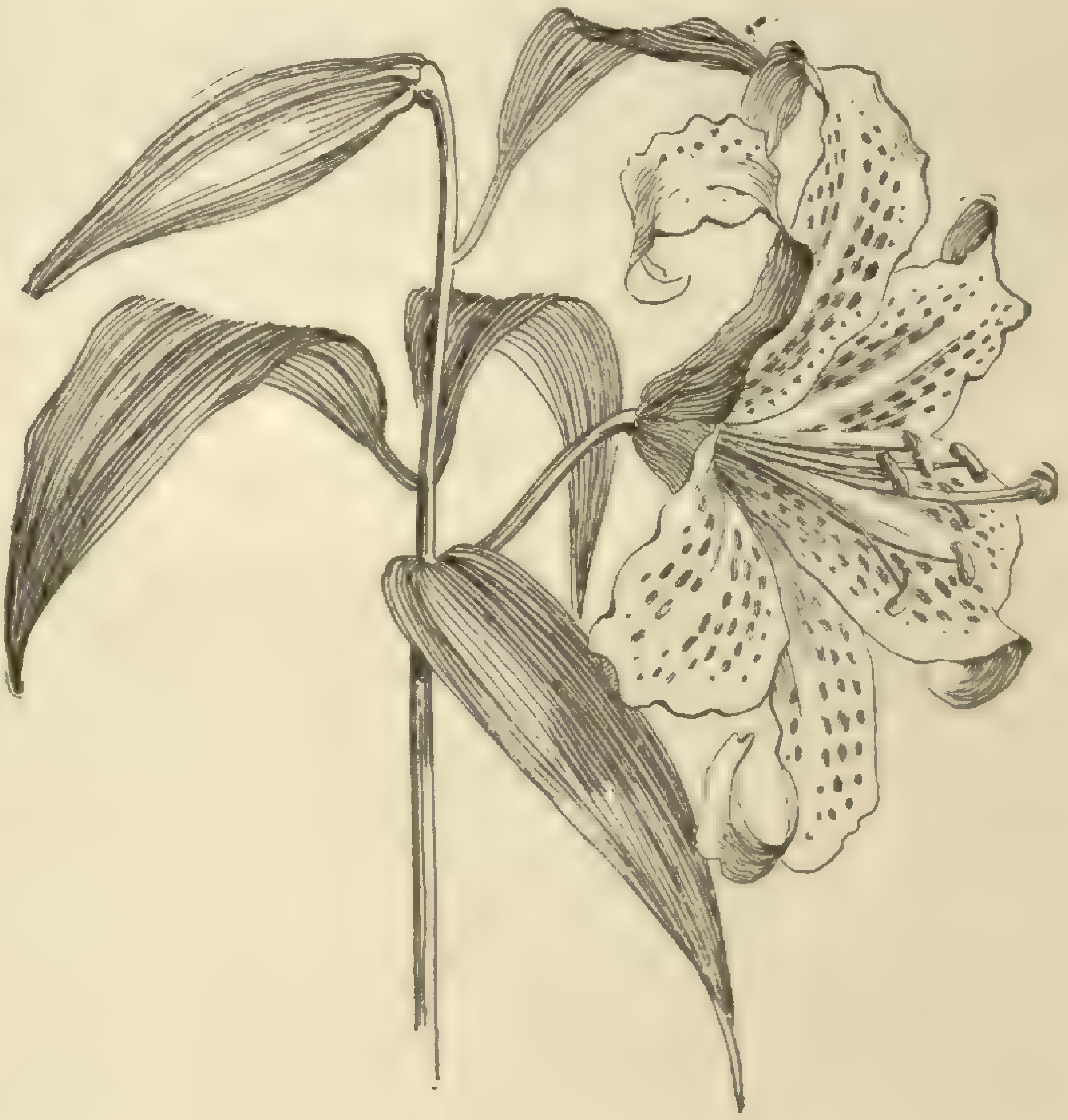

Fig. 7.—Lilium auratum.

31. L. AURATUM Lindl. Gard. Chron. **1862**: 640. July 12.

L. Dexteri Hovey, Mag. Hort. **1862**: 380.
L. Wittei Suring. in Koch, Wochens. **1867**: 294.

L. speciosum imperiale hort. Siebold in Baker, Linn. Soc. Jour. 14:235. 1874.

Bulb like *L. speciosum:* stem 6–12^{dm} high: leaves 20–30, scattered, very short petioled, glabrous, 5-nerved: flowers in a deltoid raceme with divaricate bracteolate pedicels; perianth large, wide-spreading, with segments much reflexed and somewhat twisted, white, more or less marked with bands of yellow and spots of purple, strongly papillose: anthers narrow; pollen red.

Several garden varieties have been described with botanical names. The most common have been included in the synonymy above. None deserves to rank as a botanical variety.

32. L. SPECIOSUM Thunb. Linn. Soc. Trans. **2**:332. 1794.

L. superbum Thunb. Fl. Jap. 134. 1784. [non Linn.]

L. lancifolium hort. in Guill. Arch. Bot. **2**:271. 1833.

L. Broussartii Morren, Acad. Roy. Brux. Mem. Feb. 1834.

L. eximium hort. in Kunth. Enum. Pl. **4**:259. 1843.

L. punctatum hort. in Lem. Fl. d. Serr. I. **3**:276. 1847.

L. vestale Mast. Gard. Chron. **1872**:1522.

L. Tametomo Zucc. & Spae in Baker, Linn. Soc. Jour. **14**:234. 1874.

L. Krætzeri Duch. in Baker. loc. cit.

L. Duchartrei.

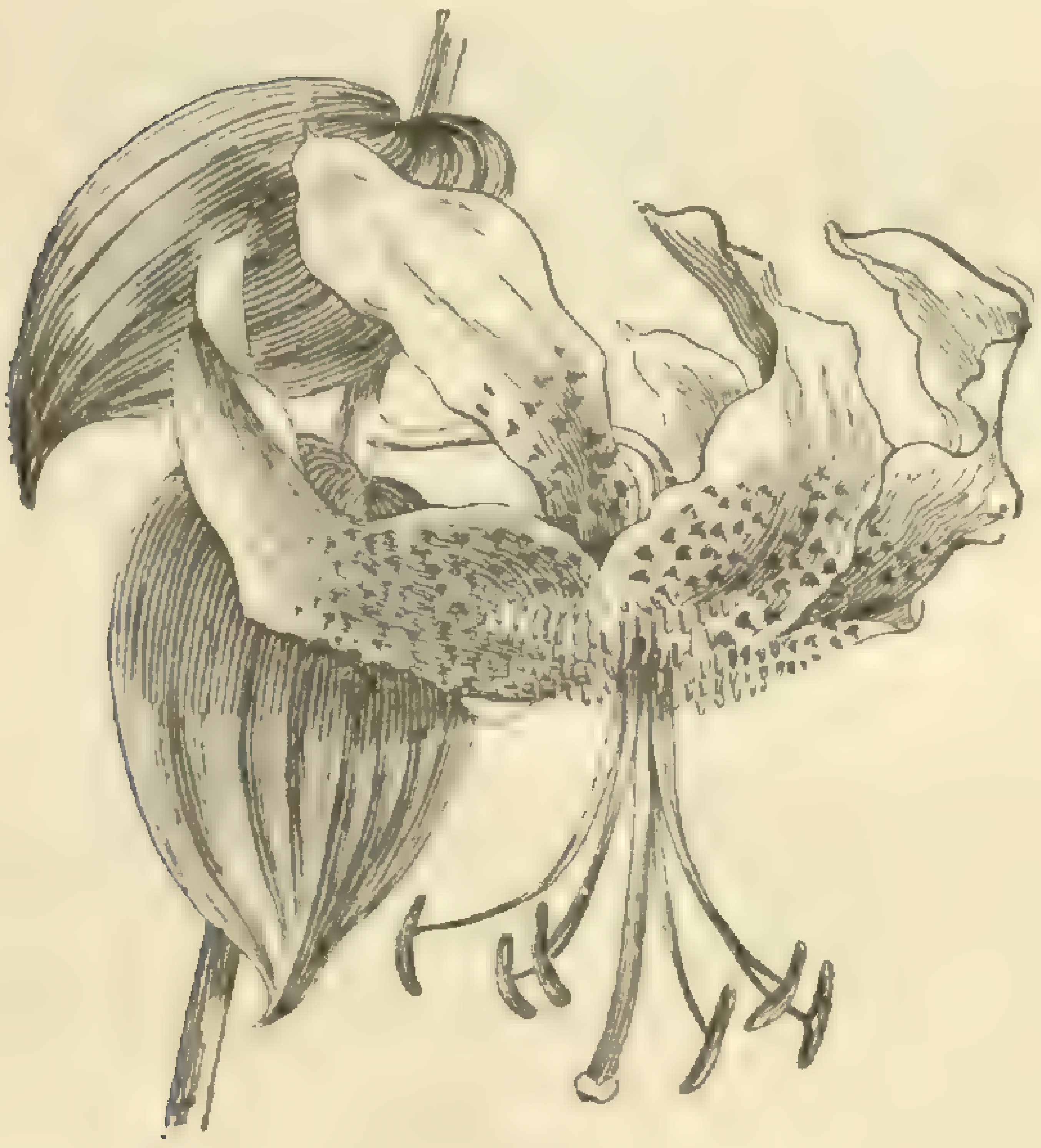

FIG. 8.—Lilium speciosum.

Bulb perennial, globose, with lanceolate scales somewhat loosely imbricated: stem 6–12^{dm} high, stiff: leaves 12–20, scattered, very short petiolate, oblong lanceolate, acute or acuminate, 5–7-nerved: flowers 3–10, racemose, on divaricate, bracteate pedicels, white more or less suffused with pink and dotted with red, strongly papillose toward the center; perianth segments vate lanceolate, much revolute: filaments much divergent: style slender, much curved; capsule obovoid, oblong, umbilicate.

Japan. One of the commonest and very best species in cultivation.

Var. RUBRUM hort. is a fine, extra strong growing sort, with darker pinkish-red flowers, and is the best for garden culture.

Var. ALBUM hort. (*L. praecox* hort.) is white or nearly so and less thrifty.

33. L. PUBERULUM Duch. Soc. Hort. Par. Jour. II. **4**:217. 1870.

L. Canadense puberulum Torr. War Dept. Pac. R. R. Rpts. **4**: 146. part 5. 1856.

L. Californicum hort. in Duch. Soc. Hort. Par. Jour. II. **4**:216. 1870.

L. Humboldtii Roezl & Leicht. in Duch. Soc. Hort. Par. Jour. II. **5**:43. 1871.

L. Bloomerianum Kelogg, Cal. Acad. Proc. **4**:60. 1872.

L. Bloomerianum ocellatum Kellogg, Cal. Acad. Proc. **5**:88. 1872.

L. Robinsonianum hort. in Baker, Linn. Soc. Jour. **14**:244. 1874.

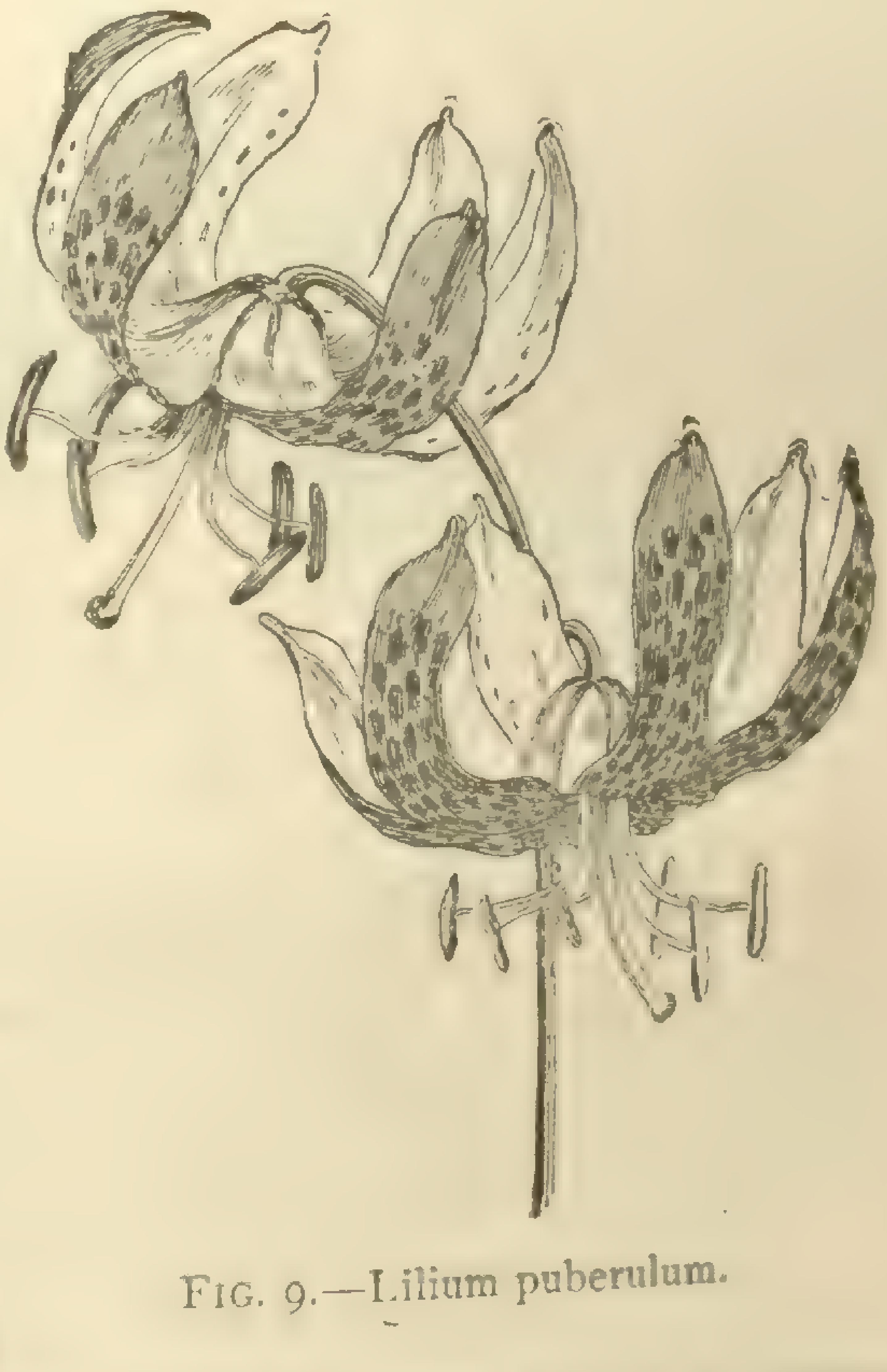

FIG. 9.—Lilium puberulum.

Bulb large, thick, oblique, perennial, not bearing rhizomes, with few scales: stem $9–15^{dm}$ high: leaves in 4–6 large whorls 10–15 leaves each, oblanceolate, acute: flowers 6–10 or more a large panicle, on nodding divaricate pedicels; perianth 7.5– long, bright orange-red thickly marked with dark spots, with acute, strongly reflexed segments which are somewhat ose at the base: style about one third the length of the ary; capsule large, obovoid, acutely 6-angled.

California. A noble garden flower, not rare in cultivation.

34. L. MARTAGON Linn. Sp. Pl. 303. 1753.

L. hirsutum Mill. Dict. n. 10. [Ed. 8.]
L. Milleri Schultes Obs. Bot. 67.
L. verticillatum Gilib. Exercit. **2** : 466. 1792.
L. versicolor Salisb. Prod. 237. 1796.
L. glabrum Spreng. Syst. **2** : 62. 1825.
L. Cattaneæ Visiani Fl. Dalm. Suppl. 32. 1852.
L. Martagon dalmaticum Maly. in Baker, Linn. Soc. Jour. **14** : 245. 1874.
L. Martagonum St. Lag. Soc. Bot. Lyon Ann. **7** : 129. 1880.

Bulb perennial, ovoid, with very many narrow scales: stem $8–15^{\mathrm{dm}}$ high: leaves several in 2–4-whorls of 6–9 leaves each, sometimes a few scattered or rarely all, oblanceolate, sessile, with 7–11 distinct nerves: flowers 3–20 in a long, loose, bracteate raceme, nodding, fragrant, varying in color from purple to dirty white, spotted, segments lanceolate, strongly revolute: pollen red: ovary shorter than the much curved style; capsule conical, acute angled, umbilicate.

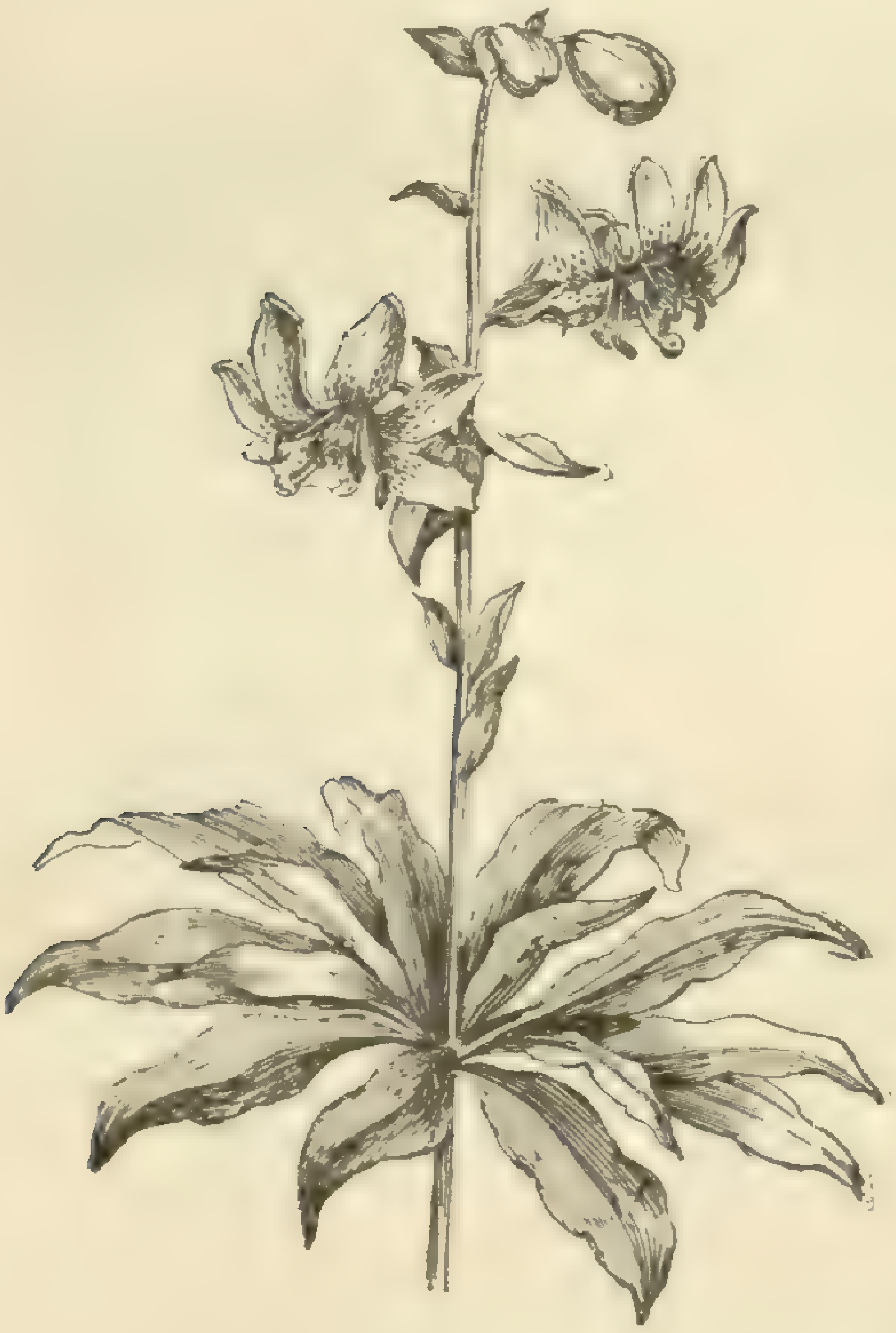

FIG. 10.—Lilium maculatum.

Central and southern Europe, to Siberia and Japan. Long cultivated in gardens, especially in Europe, where it furnishes many cultural varieties.

35. L. MACULATUM Thunb. Linn. Soc. Trans. **2**: 334. 1794.

L. Hansoni Leicht. in Baker, Linn. Soc. Jour. **14** : 245. 1874.

Bulb perennial, globose, compact: stem $9–12^{\mathrm{dm}}$ high: leaves oblanceolate, acute, frequently in a single whorl of 8–12 with some scattered, or sometimes several whorls: flowers 4–12 in a loose raceme, on erect-spreading pedicels, bright orange conspicuously spotted with purple on the lower half; perianth segments $2.5–5^{\mathrm{cm}}$ long, thick, lanceolate.

wide spreading but scarcely revolute: anthers narrow; pollen yellow: ovary clavate, deeply furrowed.

Japan. Becoming very favorably known in cultivation.

36. L. SUPERBUM Linn. Sp. Pl. 434. 1762. [Ed. 2.]

L. Martagon Walt. Fl. Carol. 123. 1788.
L. Michauxii Lam. Ency. **3**: 457. 1789.
L. autumnale Lodd. Bot. Cab. **4**: *t. 335*. 1823.
L. Michauxianum Schultes f. Syst. Veg. **7**: 258. 1829.

Bulb perennial, large, globose, cespitose, with numerous acute, closely imbricated scales: stem 12–18^{dm} tall, erect: leaves often in whorls, sometimes more or less scattered, 3–5-nerved: flowers 6–12 or even more, paniculate, bright reddish-orange, conspicuously spotted: perianth segments 7.5–10^{cm} long, lanceolate, acute: filaments strongly diverging; anthers red: ovary a little shorter than the curved style; capsule obovoid.

Canada to Georgia and west to the Mississippi river.

Var. CAROLINIANUM Chapm. Fl. S. States 484. 1860.

L. Carolinianum Michx. Fl. Bor. Am. **1**: 197. 1803.

Smaller, more slender, with fewer flowers and broader leaves.

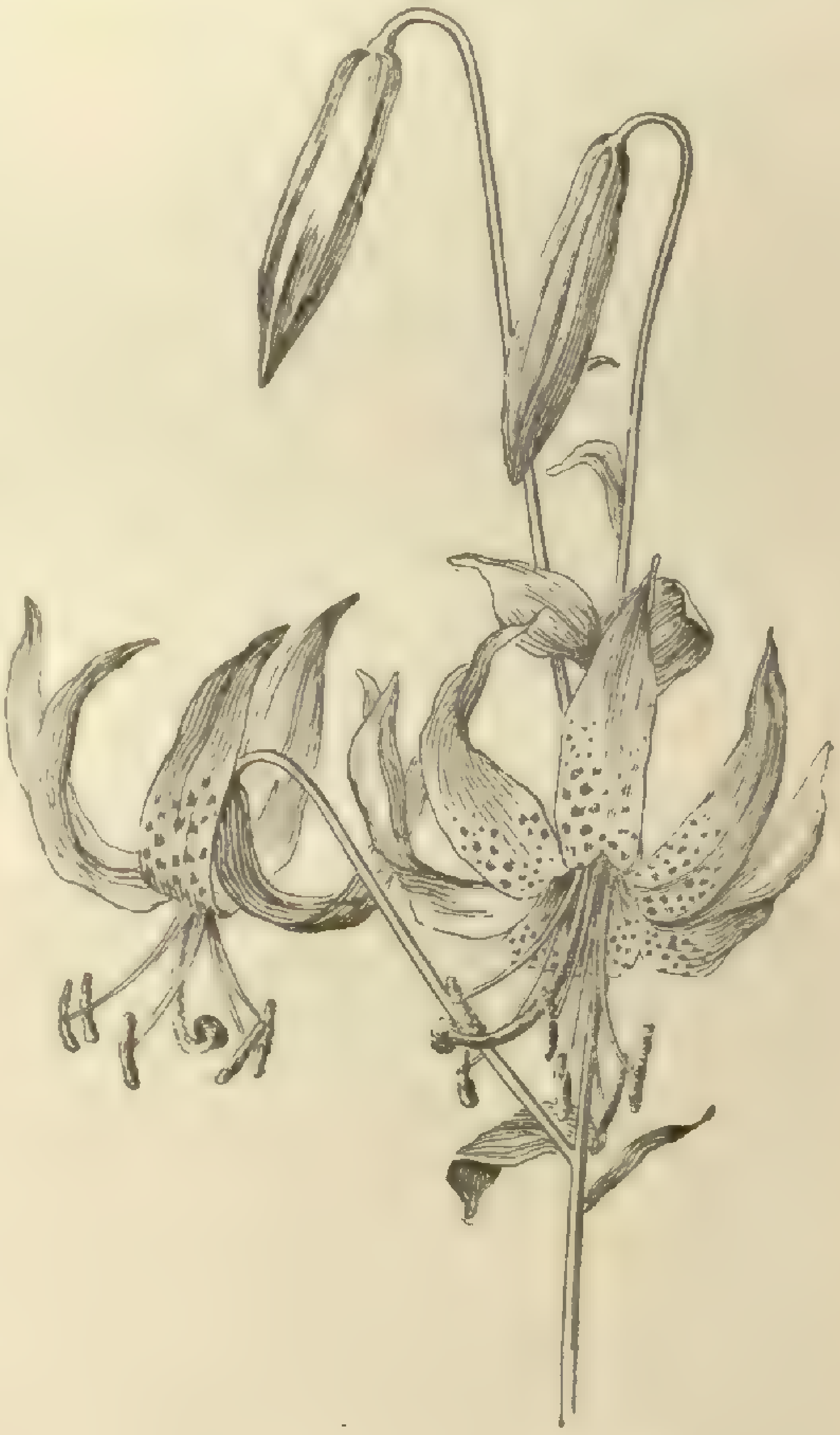

FIG. 11.—Lilium superbum.

A southern variety, in dry woods, Virginia to Florida and west to Louisiana.

37. L. OCCIDENTALE Purdy, Erythea **5**: 103. 1897.

Bulb shortly rhizomatous as in *L. pardalinum* but not branching as in that species, or forming clumps; scales overlapping closely:

stems 6–15^{dm} high: leaves scattering below but in whorls of 5–12 (or more) in the middle of the stem, lanceolate, acute, 5–10^{cm} long: flowers from a few to 15, umbellate or racemose; segments of perianth 3–6^{cm} long, the lower broadly lance-ovate, broadly overlapping at base, the upper two thirds revolute, at length to the pedicel; lower two thirds of segments light orange-red, thickly spotted with roundish black spots, upper one third a deep crimson: style straight, two thirds included in the tube: stamens little longer, spreading but little from the style; anthers oblong, 5^{cm} long, dark red.

California. "Most closely resembles *L. maritimum*, but its larger flowers with long revolute lobes strongly separate it from that species."—PURDY.

38. L. PARDALINUM Kellogg, Cal. Acad. Proc. **2**: 12. 1863.

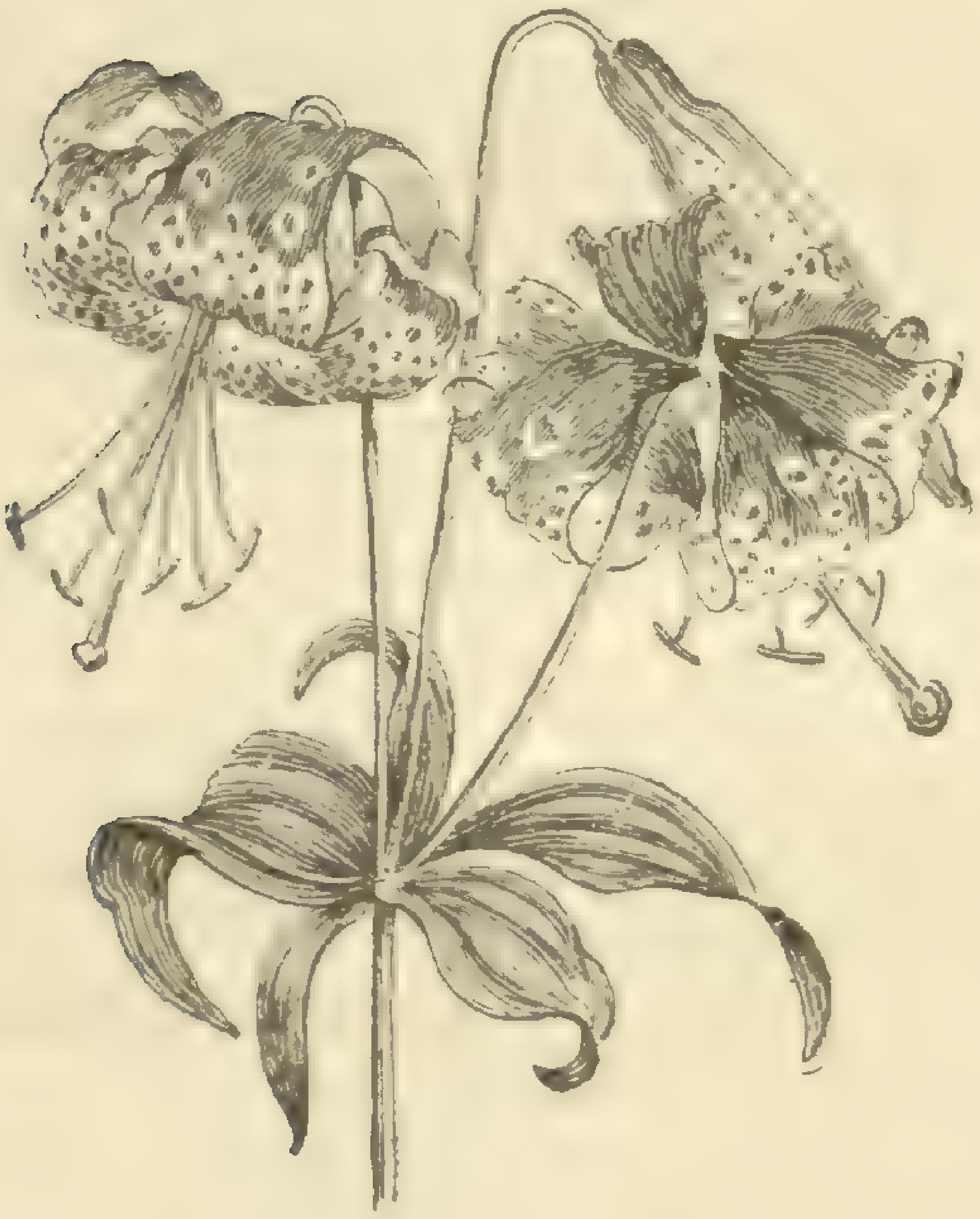

FIG. 12.—Lilium pardalinum.

L. Washingtonianum Domb. Fl. Mag. *t. 33*. 1872.
L. Californicum Domb. Fl. Mag. textu sub *t. 33*. 1872.
L. Canadense pardalinum Bolander, Cal. Acad. Proc. **5**: 206. 1872.
L. Canadense Californicum Bolander, loc. cit.
L. pardalinum pallidifolium Baker, Linn. Soc. Jour. **14**: 242. 1874.
L. puberulum hort. Leicht. in Baker, loc. cit.
L. pardalinum Bourgæi Baker, loc. cit.
L. Warei hort. in Purdy, Calif. Florist **2**: 67. 1889.

Bulb short rhizomatous, with few, loose, lanceolate, acute scales: stem 6–12^{dm} high: leaves mostly near the middle of the stem in 3–4 whorls of 9–12 leaves each, with a few scattered; flowers 3–10, loose corymbose, on long, nodding pedicels, bright red with orange toward the center, strikingly marked with large purplish-brown spots; perianth segment 5–6^{cm} long, lanceolate, strongly revolute, somewhat papillose: stamens short; anthers style scarcely longer than ovary; capsule oblong, acute angled.

California.

Var. ANGUSTIFOLIUM Kellogg in Wats. Am. Acad. Proc. 14:258. 1879.

L. Rœzli Regel, Gartenfl. 321. *t. 667*. 1870.
L. Canadense Hartwegi Baker, Gard. Chron. **1871** : 321.

A form with narrow scattered leaves.

39. L. COLUMBIANUM hort. in Gard. Chron. **1871**: 1257.

L. Canadense parviflorum Hook. Fl. Bor. Am. **2** : 181. 1840.
L. Sayi Nutt. in Duch. Hort. Soc. Par' Jour. II. **5** : 273. 1871.
L. lucidum Kellogg, Cal. Acad. Proc. **6** : 144. 1874.
L. parviflorum Holz. U. S. Nat. Herb. Cont. **3**:253. 1895.

Bulb perennial, ovoid, small, acute, with lanceolate scales: stem 4.5–9^{dm} high, slender: leaves few, mostly in whorls of four five, the upper ones frequently scattered, oblanceolate, acute, long: flowers two or three or more, umbellate, on slender nodding pedicels; perianth 4–5^{cm} long, bright orange thickly dotted with small purplish dots, segments lanceolate, reflexed: stamens less than one third the length of the perianth: style scarcely longer than ovary.

Oregon, Washington. Not uncommon in garden collections, where it succeeds fairly well.

40. L. TALIENSE Franchet, Jour. Bot. **6** : 319. 1892.

Slender, nearly 1^{m} high: stem thinly papillose-scabrous, leafless for a considerable distance near the ground: leaves slightly crowded, linear or narrow linear-lanceolate, obtuse or very acute, scattered, upper ones opposite or whorled, all 1-nerved with the margins very rough, narrowed for a long distance at the base: flowers one or two, whitish, spotted or unspotted; perianth very similar to *L. Lankongense*, but the nectar furrow bare and very smooth.

Yun-nan, China.

41. L. LANKONGENSE Franchet, Jour. Bot. **6** : 317. 1892.

Stem 3–6^{dm} high, leafy almost to the ground: leaves narrow lanceolate, 5-nerved, scarcely scabrous along the nerves and margins, crowded, the lower ones wide at the base, half clasping, obtuse, those at the middle and upper parts a little longer, acute, and those at the upper part beneath the inflorescence 3–5-whorled: flowers one or more often two or three, on long peduncles nodding when they first come out; perianth white or purple, spotted with black, with the segments oblong, somewhat incurved above the base, open, nectar furrow papillose: stamens divergent, with yellow anthers: style two to three times longer than the ovary.

Yun-nan, China.

42. L. AVENACEUM Fischer in Regel, Gartenfl. **1865** : 290.

L. Martagon Ledeb. Fl. Ross. **4** : 149, ex parte, 1814.

Bulb globose, small, perennial, with very many lanceolate scales: stem 3–6^{dm} high: leaves few, scattered or somewhat whorled, oblanceolate, 7–10^{cm} long: flowers few, nodding, perianth small, 2.5–3.5^{cm} long, revolute, bright reddish-yellow, with a few fine dots, segments lanceolate: ovary half as long as the curved style.

Kamchatka, Manchuria, Kurile islands, Japan.

43. L. MONADELPHUM Bieb. Fl. Taur, **1**: 267. 1808.

L. Loddigesianum Schultes f. Syst. Veg. **7**: 416. 1829.

L. Szovitsianum Fisch. & Lall. Ind. Sem. Hort. Petrop. **6**: 58. 183[illegible].

L. colchicum hort. in Planch. Fl. d. Serr. I. **5**: 507. 1849.

Bulb perennial, ovoid, with several lanceolate scales: stem 6–15^{dm} high: leaves 30–50, scattered, linear-lanceolate or oblanceolate, distinctly many-nerved: flowers 2–12, sometimes 20–30, in a raceme, nodding, bracteate, fragrant, yellow, with a few small spots and tinged at the base and tip with purple: perianth segments 6–8^{cm} long, oblanceolate, recurved from the middle, smooth at the base inside: pollen red: ovary half as long as the style; capsule obovoid, umbilicate.

Persia.

Var. LEDEBOURI Baker, Linn. Soc. Jour. **14**: 246. 1874.

L. pyreniacum Led. (non Gouan.) Fl. Ross. **4**: 151. 1814.
L. Ledebourii Boiss. Fl. Orient. **5**: 175. 1867.

Caucasus. Dwarfer than the species, with narrower linear leaves.

44. L. POLYPHYLLUM D. Don in Royle, Ill. Bot. Him. 388. 1839.

L. punctatum Jaquem. in Duch. Soc. Hort. Par. Jour. II. **4**: 545. 1870.

Stem 9–12^{dm} high: leaves 40–60, scattered, ascending, the wer oblanceolate, 10–13^{cm}, the upper narrower and linear: wers 4–10, in a loose raceme, on nodding pedicels, bright yelw with vinous purple spots, fragrant; segments of the perianth long, oblanceolate, revolute from the middle: ovary two rds as long as the much curved style; capsule obovoid.

Western Himalayas.

45. L. CARNIOLICUM Bernh. in Mert. & Koch. Deutsch. Fl. 2:536. 1838?

L. Chalcedonicum Linn. Sp. Pl. 434, ex parte, 1762. [Ed. 2.]
L. alpinum Kit. (?), Linnæa **32**: 335. 1863.
L. Ponticum K. Koch (?), Linnæa **22**: 234. 1849.

Bulb perennial, ovoid, with several lanceolate scales: stem high: leaves 30–40, scattered, lanceolate or linear-lanceo, the lower 5–7.5^{cm} long, flat, distinctly many-nerved, with ate margins: flowers in a small raceme, nodding; perianth long, orange or red, with minute spots, with lanceolate arply revolute segments which are papillose toward the base: en yellow: ovary equaling the clavate style; capsule 4^{cm} long, obtuse angled.

Southern Europe. A fine species, but rare in cultivation.

46. L. MAXIMOWICZII Regel, Ind. Sem. Hort. Petrop. **1866**: 26.

L. Leichtlini Hook. f. Bot. Mag. *t. 5673*. 1867.
L. pseudo-tigrinum Carr. Rev. Hort. **39**: 411. 1867.
L. Leichtlini majus Wils. Jour. Hort. **1873**: 371.
L. jucundum hort. Bull in Elwes Mon. Gen. Lil. *t. 40*. 1877.

Bulb perennial, globose, small, with few, wide, acute, thick, ely imbricated scales: stem 6–9^{dm} high, slender, decumbent the base: leaves 30–40, scattered, linear, ascending, flat, 3-nerved: flowers few, in a loose corymb, on spreading pedicels, either bright lemon-yellow, light orange or red, thickly dotted with dark purple, and tinged with purple on the outside; segments lanceolate, 5–7.5^{cm} long, strongly revolute, thickened at the tip: anthers reddish-brown: ovary slender, one third the length of the curved style.

Japan. There are several good garden varieties, but none deserving the distinction of a botanical name.

47. L. TESTACEUM Lindl. Bot. Reg. Misc. **1842**: 51.

L. Isabellinum Kunze in Mohl & Schlecht. Bot. Zeit. **1**: 609. 1843.
L. peregrinum hort. Germ. in Lem. Fl. d. Serr. I. **1**: 192. 1845.
L. excelsum hort. in Seem. in Harting Parad. Vindob. 2. 1845 cir.
L. altissimum hort. in Duch. Soc. Hort. Par. Jour. II. **4**: 215. 1870.

Bulb perennial, globose: stem 1.5–2^{m} high: leaves 60–100, scattered, linear, ascending, 3–5-nerved, the lower ones 7.5–10 long, gradually becoming smaller upward: flowers 2–10, umbellate, nodding, fragrant, creamy-yellow, with sometimes a few minute reddish dots, slightly papillose; perianth segments 6–7.5^{cm} long, strongly revolute: filaments half as long as the perianth; pollen red: ovary a little more than half as long as the curved style.

Not known in the wild state, and thought to be a hybrid. A fine, stately plant, with delicate, pretty flowers.

48. L. OCHRACEUM Franchet, Jour. Bot. **6**: 319. 1892.

Bulb small, with few fine lanceolate scales: stem slender, 9–12^{dm} high, bare for a long distance at the base: leaves crowded at the middle, smooth, 1-nerved, or the lower ones slightly 3-nerved, narrowed at the base, subpetiolate, linear-lanceolate or lanceolate, acute or acuminate, all scattered: flowers 1–3, at first nodding, spotted with yellow; perianth tubular for one-third its height, segments oblong, incurved subrevolute; nectar furrow bare, smooth: stamens less than half as long as the perianth; anthers yellow: style three times as long as the ovary.

Yun-nan, China.

49. L. FARGESI Franchet, Jour. Bot. **6**: 317. 1892.

Bulb ovate, small, with 10–15 fleshy scales: stem slender, 10^{dm} high, leafless below, then leaves somewhat crowded, linear, h margins narrowly revolute: flowers sometimes solitary, metimes 2–10 in a pyramidal raceme, all with long pedun- at the axils of the persistent leaves, nodding when young, rizontal when fully flowered, or nearly erect; perianth mall, 4–5^{cm} long, yellow, thickly spotted with purple on the ide, and smooth without; segments lanceolate, immediately xpanded, then recurved the whole length, with several fim- ate crests running parallel with the nectar furrow, which is illose: stamens half the length of the perianth; pollen ow: style a little longer than the ovary; capsule ovate or nearly square, truncate at the top.

Su-tchuen, China.

50. L. POMPONIUM Linn. Sp. Pl. 302. 1753.

L. angustifolium Miller, Dict. n. 6. 1768. [Ed. 8.]

L. rubrum LaM. & DC. Fl. Fr. 213. 1805. [Ed. 3.]

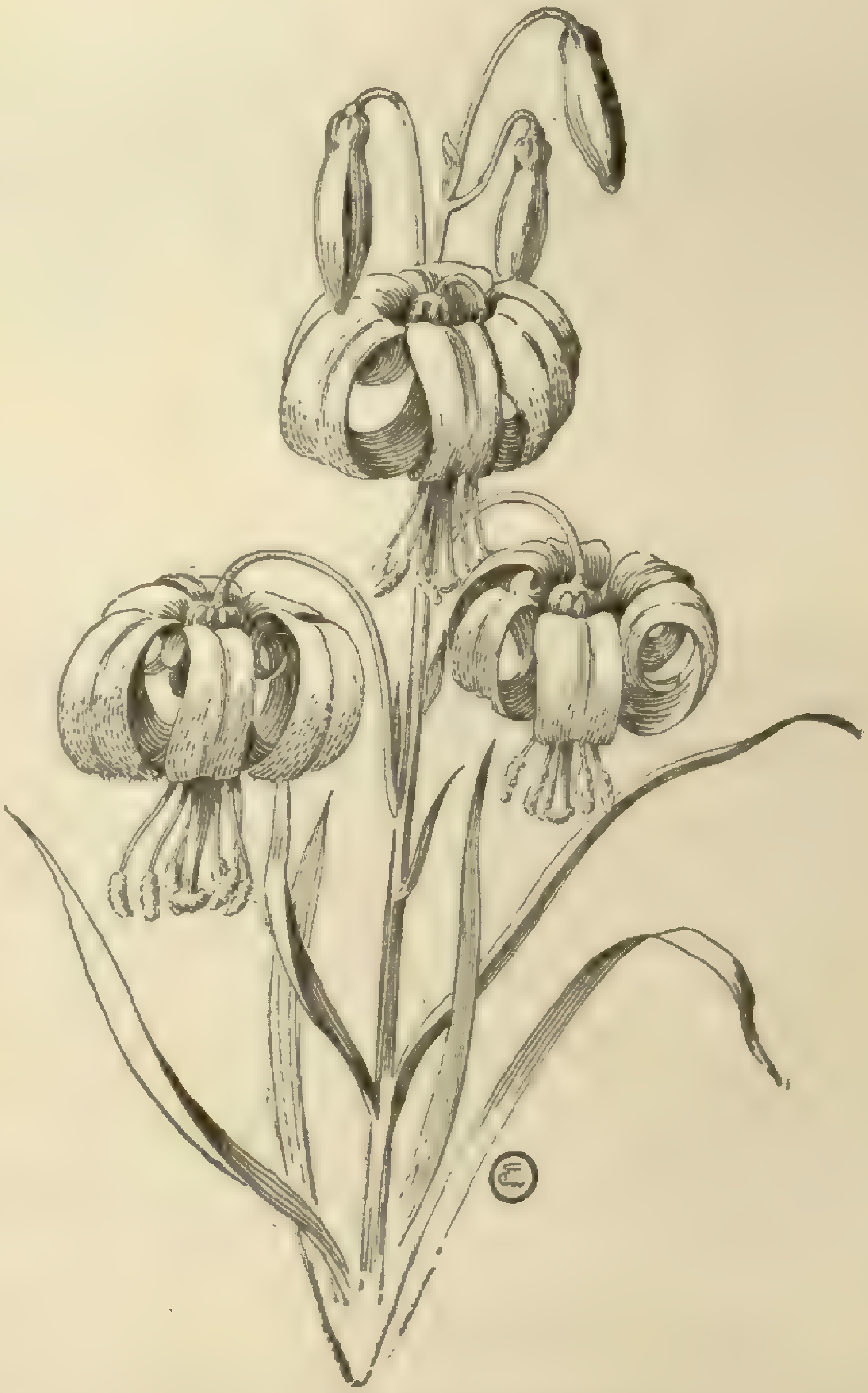

FIG. 13.—Lilium pomponium.

Bulb perennial, ovoid, with several lanceolate scales: stem 6–9^{dm} high, thick, stiff: leaves 100 or more, scattered, narrow linear, ascending, the lower ones 5–10^{cm} long, the upper shorter and narrow linear: flowers 2–15, race- e, nodding, often brac- ate, cinnabar-red, thick- spotted and papillose hin, fragrant; perianth ments 4–5^{cm} long, anceolate, wide: pollen ovary a little shorter n the style; capsule obovoid, umbilicate.

Northern Italy and southern France. An excellent lily for garden planting, especially the yellow *L. pomponium aureum* hort.

Var. PYRENAICUM Baker, Linn. Soc. Jour. **14**: 249. 1874.

L. Pyrenaicum Gouan, Ill. 25. 1773.
L. flavum Lam. & DC. Fl. Fr. 213. 1805. [Ed. 3.]

Pyrenees. A more robust plant, with wider leaves distinctly 3-nerved: flowers larger, yellow.

51. L. CHALCEDONICUM Linn. Sp. Pl. 302, ex parte, 1753.

L. miniatum Salisb. Prod. 237. 1796.
L. pomponium DC. in Red. Lil. *t. 7.* 1802–16.
L. Pyreniacum Baumg. (non Gouan.) Enum. Stirp. Transyl. **1**: 301. 1816–46.
L. noricum Bernh. in Steud. Nom. ed. ii, **2**: 44. 1840.
L. gracile Ebel, Zwölfe Tage auf Montenegro 8. 1842.
L. Albanicum Griseb. Spicil. Fl. Rumel. **2**: 385. 1844.
L. Byzantinum hort. in Duch. Soc. Hort. Par. Jour. II. **5**: 280. 1871.
L. Jankae Kern. in Oestr. Bot. Zeitschr. **27**: 402. 1877.
L. Heldreichii Freyn. Flora **63**: 28. 1880.

Bulb perennial, ovoid, with several lanceolate scales: stem $9–12^{\rm dm}$ high, stiff: leaves 100 or more, crowded, ascending, 3–5-nerved, with the edges and veins on the lower side distinctly papillose: flowers few, in a raceme, with nodding peduncles: perianth $4–5^{\rm cm}$ long, bright red, unspotted, or sometimes with minute dots, rarely yellow; segments oblanceolate, much revolute, abundantly papillose: ovary nearly as long as the style.

Greece. A very excellent garden plant.

52. L. CALLOSUM Sieb. & Zucc. Fl. Jap. **9**: 86, *t. 41.* 1835.

L. pomponium Thunb. (non Linn.) Fl. Jap. 134. 1784.

Bulb small, perennial, with few lanceolate scales: stem $3–9^{\rm dm}$ high: leaves 30–40, scattered, linear, 3–5-nerved, edges narrowly revolute: flowers 2–12 in a narrow loose raceme, on short nodding pedicels; perianth $2.5–3.8^{\rm cm}$ long, bright scarlet: filaments short, with scarlet anthers: ovary as long as the clavate style; capsule ovoid.

Japan and the Loo-choo islands.

53. L. SUTCHUENSE Franchet, Jour. Bot. **6**: 318. 1892.

L. tenuifolium punctatum Bur. & Franch. in Franch. loc. cit.
L. Chinense Baroni, Nuov. Giorn. Bot. It. **2**: 333. 1895.
L. Chinense atropurpureum Baroni, op. cit. 335.
L. Biondii Baroni, op. cit. 337.

Bulb small, broad ovate, scales fleshy, ovate-lanceolate, about 15–18 imbricate: stem slender, 8–10^{dm} high, leafless below: leaves scattered, only slightly crowded, linear, the lower and upper ones one third the length of the others, those in the middle [illegible]–15^{cm} long, smooth: flowers solitary, or terminating 2–4 long stiff branches, nearly erect when young; perianth intensely reddish-orange, often spotted with black; segments much recurved from the middle, papillose on the inside: stamens shorter than the perianth, with the filaments smooth and the pollen golden: style 3–4 times as long as the ovary.

Su-tchuen, China. Shen-si, *legit* Giraldi, *fide* Baroni. "The plant is more robust than *L. tenuifolium*, the leaves equally linear but a little larger, flowers almost twice as large, covered with black spots, style two or three times longer than the ovary."—Franchet.

54. L. TENUIFOLIUM Fisch. Ind. Sem. Hort. Gorenk. 8. 1812. [Ed. 2.]

L. linifolium Hornem. Hort. Hafn. **1**: 326. 1813.
L. pumilum DC. in Red. Lil. *t. 378*. 1815 cir.
L. puniceum Sieb. & DeVriese. Ann. Hort. Pays-Bas 23. 1861.
L. tenuifolium stenophyllum Baker, Linn. Soc. Jour. **14**: 251. 1874.

Bulb small, globose, with several lanceolate scales: stem [illegible] high, slender: leaves 20–50, scattered, very narrow linear, ascending, with revolute margins: flowers 1–20, racemose, on nodding pedicels 5–7.5^{cm} long, rich scarlet, unspotted; perianth segments 2.5–5^{cm} long, much revolute: pollen red: ovary two thirds as long as the slender style.

Siberia. A deserving favorite in gardening, growing readily from seeds or from bulb scales.

55. L. BOLANDERI Wats. Am. Acad. Proc. **20**: 377. 1885.

Bulb ovate, of numerous lanceolate scales 2.5–3.5^{cm} long: stems 15–90^{cm} high, 1–2-flowered: leaves mostly verticillate and approximate, oblanceolate, acute, glaucous beneath : flowers horizontal or somewhat nodding, dingy purple or dark brownish-red, becoming somewhat paler, spotted ; the segments 3–4$^{\text{cm}}$ long, but slightly spreading, rarely at all recurved : anthers 4–6$^{\text{mm}}$ long : ovary and style 18–20$^{\text{mm}}$ long.

In Red Hills, Humboldt county, California, by Bolander, near Arcata. between Illinois and Smith rivers near state boundary. Allied to *L. parvum* and *L. maritimum*. Rare.

56. L. GRAYI Wats. Am. Acad. Proc. **14** : 256. 1879.

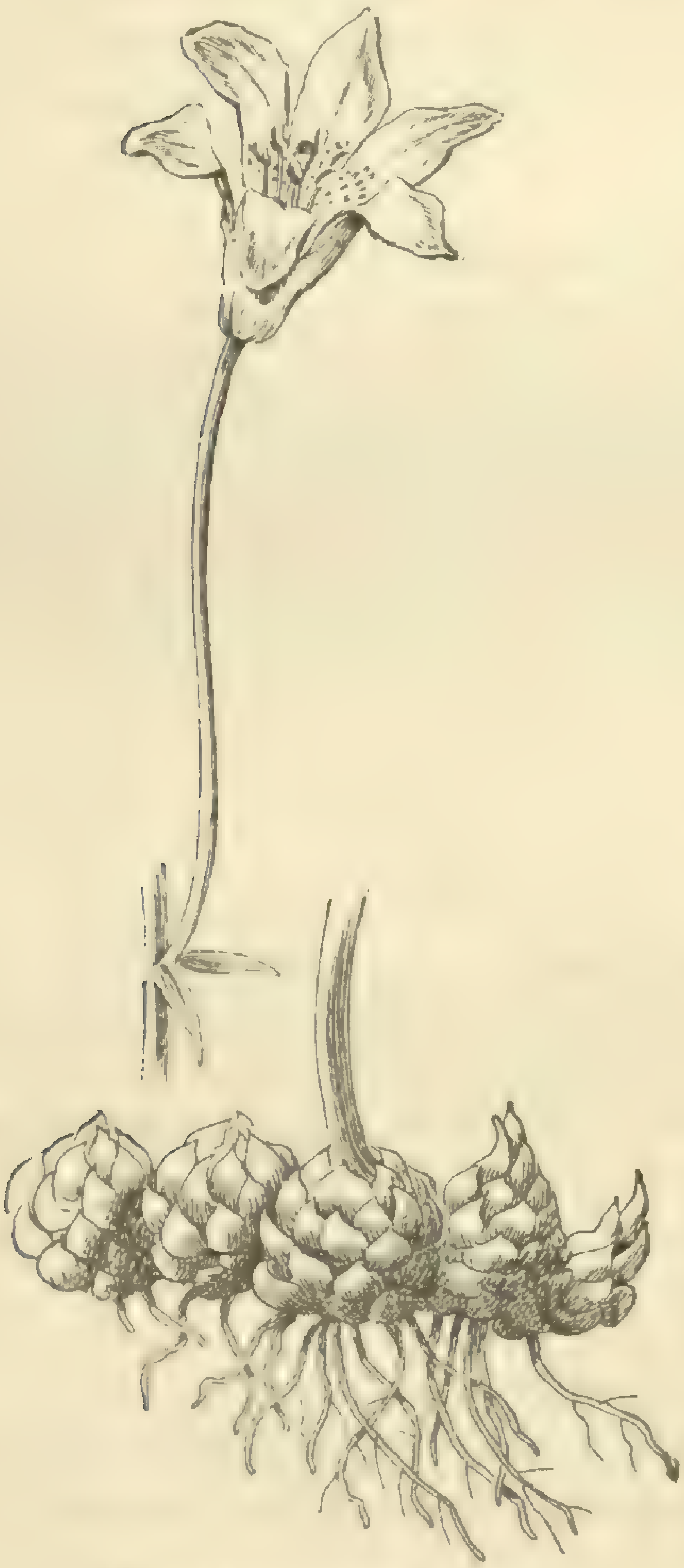

FIG. 14.—Lilium parvum.

Leaves lanceolate, 5$^{\text{cm}}$ long or less, in whorls of 4 to 8, not acuminate : flowers 4–6$^{\text{cm}}$ long, horizontal, often solitary ; segments spreading but not recurved, deep reddish-orange, covered throughout with purplish spots.

Virginia and North Carolina. Becoming somewhat common in cultivation. Closely related to *L. Canadense.*

57. L. PARVUM Kellogg, Cal. Acad. Proc. **2** : 179. 1863.

L. Canadense Walkeri Wood. Phil. Acad. Proc. **1868** : 166.
L. Canadense parvum Baker, Linn. Soc. Jour. **14** : 241. 1874.
L. parvum luteum Purdy, Erythea **5** : 105. 1897.

Bulb of *L. Canadense* : stem 3–4.5$^{\text{dm}}$ high : leaves partly whorled, or the upper ones scattered: flowers few to many, upright or nearly so, bright reddish-orange, thickly dotted ; perianth segments 2.5–4$^{\text{cm}}$ long, acute, more or less reflexed above the middle : ovary half as long as style.

Sierra Nevada mountains, California.

58. L. NITIDUM hort. Bull. in Baker, Gard. Chron. **1880**: 198.

Bulb oblong, subrhizomatous, with crowded, appressed, lance-ate scales: stem 4.5^{dm} long below the inflorescence, stout, bear-ng four whorls of leaves and several additional scattered ones: aves up to 20 in a whorl, lanceolate: panicle deltoid, 15–25^{cm} ng, of 10–20 flowers; lower pedicels 5–7.5^{cm} long, spreading th cernuous tips in the flowering stage, arcuate ascending in the fruiting stage; perianth bright yellow, with copious small d-brown dots, 4^{cm} long; segments lanceolate, under 13^{mm} broad, rmanently connivent in the cup in the lower half, revolute in the upper half: filaments above 2.5^{cm} long; anthers oblong, bright llow: ovary oblong, 13^{mm} long; style as long as the ovary, much curved.

This species is not known in our gardens, and is hardly represented in our herbaria. It should have further study.

59. L. MARITIMUM Kellogg, Cal. Acad. Proc. **6**: 140. 1874.

L. Canadense parviflorum Bolander in Wats. Am. Acad. Proc. **14**: 256. 1879.

Bulb small, conical: stem rather low: leaves usually scat-tered, narrow, often obtuse: flowers solitary or few, horizontal, 5 long, deep reddish-orange, spotted below: segments curved above: style and stamens short; anthers 4^{mm} long: capsule long and narrow.

60. L. CANADENSE Linn. Sp. Pl. 303. 1753.

L. penduliflorum DC. in Red. Lil. *t. 105*. 1802–16.
L. pulchrum Salisb. Prod. 237. 1796.
L. pendulum Spae Mem. Gen. Lis. 28. 1845.
L. Canadense minus Wood, Phil. Acad. Proc. **1868**: 166.

Bulb annual, rhizomatous, with short, thick, obtuse scales: em 3–12^{dm} high, slender, erect: leaves oblanceolate, acute, 5–10^{cm} long, 5–7-nerved, usually mostly in whorls: flowers to several, somewhat umbellate; perianth 5–9^{cm} long, wide nnel-shaped, in various shades of yellow, orange and red with numerous dark spots ; segments oblanceolate, more or less revolute above the middle : filaments short : ovary a little shorter than the style ; capsule conical.

Eastern North America from New Brunswick to Georgia, and west to the Mississippi river. A good species in cultivation. Varies considerably in degree of revoluteness and in color. Those with red flowers may take the name L. CANADENSE RUBRUM Britton (Torr. Bot. Bull. **17** : 125. 1890). Bright yellow sorts may be called L. CANADENSE FLAVUM hort. (nom. nov.).

61. L. PURDYI, nom. nov.

L. Bakeri Purdy, Erythea **5** ; 104. 1897.

Bulb ovoid, exactly as in *L. Columbianum :* stem 6-18^{dm} high, rather stout : leaves lanceolate, mostly in whorls : inflorescence racemose ; flowers few to ten, horizontal, orange-red, thickly dotted with maroon, very fragrant, buds nodding ; segments of perianth 3^{cm} long, acute, lower half of segments forming a closely constricted tube from which upper half spreads rotately, tips not recurved : stamens exserted, a little shorter than the segments, not spreading much from the straight style, which they exceed a little.

Washington and British Columbia.

62. L. CORDIFOLIUM Thunb. Linn. Soc. Trans. **2** : 332. 1794

Hemerocallis cordata Thunb. Fl. Jap. 143. 1784.
Saussurea cordifolia Salisb. Linn. Soc. Trans. **8** : 11. 1807.
L. Glehni F. Schmidt ? Reis. Amurl. 187 (Acad. Imp. Sci. St. Petr. Mem. xiii, no. 2). 1868.

Bulb perennial, globose, cespitose, with scales thicker, more rugose, and less regular than in *L. giganteum :* stem 9-12^{dm} high, leaves at the base cordate, long-petiolate, tinged with red, those on the stem cordate, ovate, petiolate : flowers 3-10, in a short raceme ; perianth narrow, funnel-shaped, 10-15^{cm} long ; segments oblanceolate, white, with large violet-brown patches on the lower half of the outer segments.

Japan. Sometimes seen in collections, but difficult of cultivation.

63. L. GIGANTEUM Wallich. Tent. Fl. Nep. 21, *t. 12-13*. 1824.

L. cordifolium D. Don. (non Thunb.) Prod. Nep. 52. 1825.

Bulb perennial, globose, cespitose: stem 1.5–3^{m} high: radi- l leaves green; cauline leaves 12–20, scattered, ovate, acute, eeply cordate at the base, reticulate veined, petiolate, gradually maller above: flowers 12 20, in a raceme, slightly nodding, hite, tinged with purple inside and green outside, fragrant, 12-15^{cm} long: stamens less than one-third the length of the perianth; anthers yellow: ovary cylindrical.

Himalayas. Found in large collections, but not generally successful in cultivation.

64. L. MIRABILE Franchet, Jour. Bot. 6: 310. 1892.

Nearly 1.2^{m} high, slender: leaves thin, paperlike, unspotted, alternate, cordate, broad, ovate, acuminate: inflorescence ntrifugal: flowers 7–15, nearly horizontal; perianth white, nged with violet on the margins outside, narrowly tubular, the s moderately opened, 16-18^{cm} long, with the segments oblong- near, much attenuated: stamens scarcely exceeding half the rianth, with short anthers and yellow pollen: ovary 2.5^{cm} long; style 6–7^{cm} long, slender.

Su-tchuen, China.

BURLINGTON, VERMONT.

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THE ECOLOGICAL RELATIONS OF THE VEGETATION ON THE SAND DUNES OF LAKE MICHIGAN.

HENRY CHANDLER COWLES.

[*Concluded from p. 308.*]

D. THE ESTABLISHED DUNES.

1. *The basswood-maple series.*

It was shown in another place how the steep lee slopes of the wly advancing dune-complex are first captured by social pernial herbs like Ammophila and Asclepias. Then shrubs like rnus, Salix, and Prunus grow up and gradually drive out the rbs which grew there first, because they are ill-adapted to the ade. With these shrubs there often develop many young trees the basswood, *Tilia Americana.* As these trees grow rapidly, s not long before the thicket becomes a little forest, in which e dominant tree is the basswood. The basswood dune, more an any other type of established dune, is *sui generis.* It is to found along the entire coast between Dune Park and Glen ven.

The conditions that determine the development of the wonrfully characteristic flora are very obscure. The basswood nes are always very steep and relatively near the lake. Unlike other established dunes there is no approach to a vegetation et; the sandy soil is loose and bare and evidently more or s shifting. The movement of the sand is due directly to gravy and only indirectly to the wind. The only obvious condin which favors the rich development of plants is the almost plete protection from the wind.

The trees of the basswood dunes grow as thickly together as s ever grow, and much more thickly than in any other dune ests. Everywhere the basswood is the dominant tree; no r tree begins to approach it in importance. although *Populus* *monilifera* is often common. At the south end of the lake *Sassafras officinale* grows with the basswood in abundance. Trees that occur occasionally along the coast in this association are *Quercus coccinea tinctoria*, *Fraxinus Americana*, *Juglans cinerea*, *Ulmus fulva*, *Ostrya Virginica*, *Acer saccharinum*, *Betula papyrifera*, *Abies balsamea*, *Pinus Strobus*, *Tsuga Canadensis*, *Thuya occidentalis*.

One of the remarkable features of the basswood dunes is the luxuriant development of lianas. Scarcely anywhere away from the river bottom forests is there such a development of climbers in this region. *Celastrus scandens*, *Vitis cordifolia*, and *Rhus Toxicodendron* occur almost everywhere. *Ampelopsis quinquefolia* and *Smilax hispida* are not infrequent. The great liana development may be correlated, perhaps, with the dense growth of trees.

Shrubs are abundant about the margins of the miniature forests and in the more open places. Often these may be regarded as relicts of a former exclusive shrub vegetation. *Prunus Virginiana* and *Cornus stolonifera* are the most common tall shrubs, *Rosa Engelmanni* the most common low shrub. At the south end of the lake *Hamamelis Virginiana*, *Ptelea trifoliata*, *Rhus Canadensis*, and *Celtis occidentalis pumila* are common and very characteristic. The only herb that can be regarded as characteristic of this association is *Smilacina stellata*. *Elymus Canadensis* occurs in the open places. Many other herbs are occasionally present, but there is no necessity for mentioning them. The slopes of the crateriform depression in *fig. 22* have most of the typical plants of a basswood dune. The bare trees are chiefly basswoods, the others pines.

By all odds the most remarkable feature of the flora on the basswood dunes is its decided mesophytic flavor. The majority of the above-named species are usually pronounced mesophytes. Indeed, along the wooded bottoms of the Desplaines river far from dunes and dune influences, the following of the above plants may be found growing together: Tilia, Fraxinus, *Ulmus fulva*, Populus, Celastrus, Vitis, *Rhus Toxicodendron*, Ampelopsis, Smilax, Prunus, Cornus, Hamamelis, Ptelea, and Celtis. Thus half of the entire number recorded above are found in a single river m forest. Of the fifteen most characteristic plants of the basswood dunes at the south end of the lake, eleven are found along the Desplaines bottoms; two of the remaining four, sassafras and Smilacina, are common as mesophytes. Only two of the fifteen, *Rhus Canadensis*, and Rosa, are commonly xerophytic.

Apparently the life conditions on the basswood dunes are anything but similar to those of the river bottoms. The former appear to be xerophytic, the latter mesophytic and inclining to hydrophytic. The soil of the dunes is sand with scarcely any humus at all, and the slight water content is made less by the steepness of the slope. In the river bottom there is a deep alluvial soil rich with humus and with an abundance of water. Nor is the river bottom flora on the dunes the vanguard or the relict of a river bottom flora. At the south end of the lake, at least, the basswood dunes and river bottoms are separated from each other by many kilometers. The likeness of the floras suggests a likeness of conditions in the two apparently very dissimilar habitats. What this likeness is, if it exists at all, cannot easily be seen.

It is this river bottom flora on the dunes that furnishes the best examples of anatomical variation due to habitat conditions. Most remarkable gross variations are found in the leaves of nearly all the species. Celtis, a tall tree on the bottoms, is a thorny shrub on the dunes. The tissues, also, are highly modified so as to meet the requirements of the dune conditions. These great variations, not alone in a single species, but in a plant society transported, as it were, from the river bottoms to the dunes, will supply a large part of the material for the second or anatomical portion of this paper. It is also the author's intention to experiment with the river bottom and dune forms of the various species, and endeavor to determine whether or not these changes can take place within a single plant generation.

The development of an undergrowth of shrubs and herbs on the steep basswood dunes tends more and more to stop the sifting of the sand between the plants. The partial decay of the

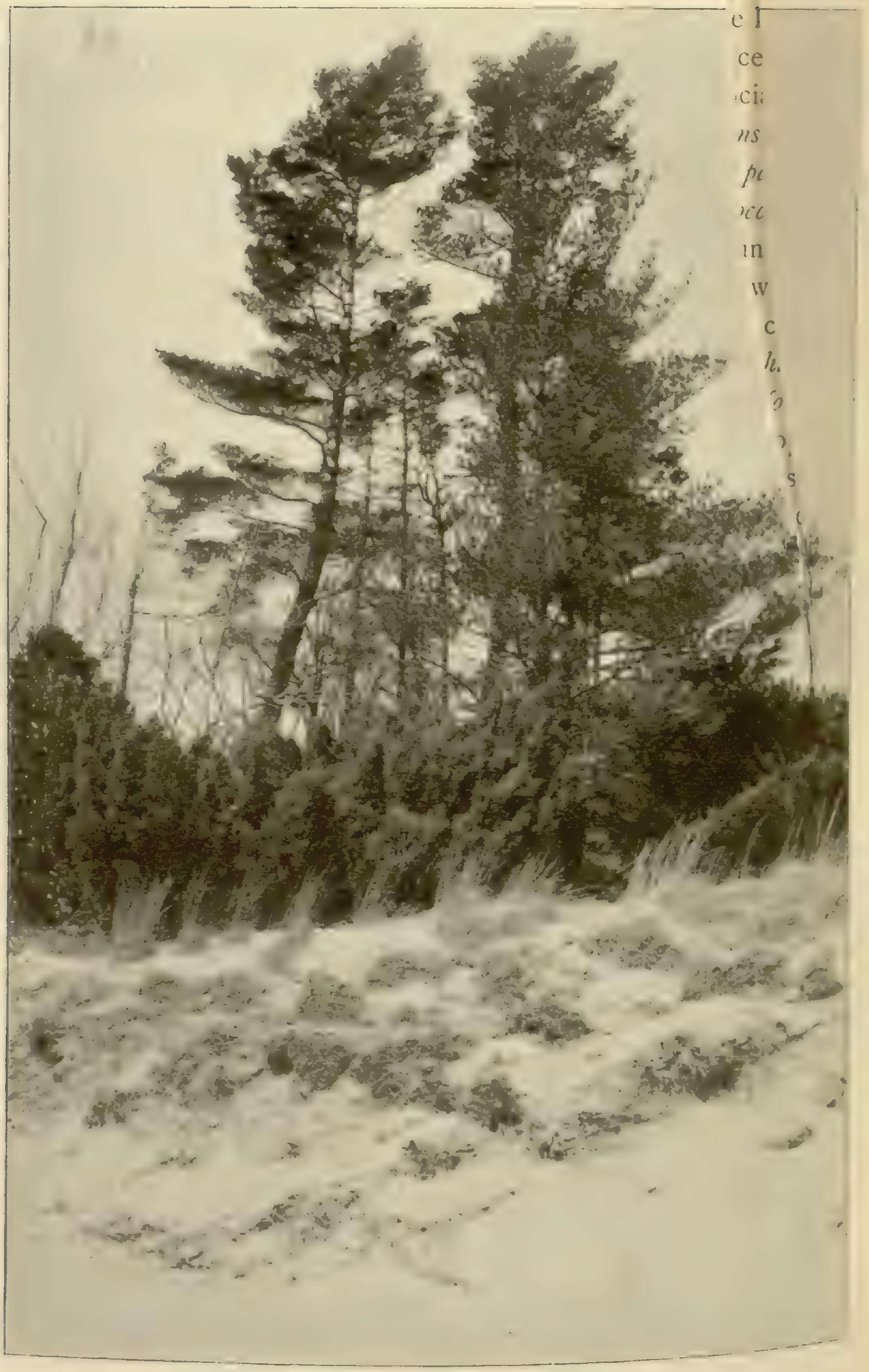

FIG. 19.—Summit of a coniferous dune at Dune Park. The trees are white pines. The shrubs in front of them are junipers; those at the left, cedars. The grass in the foreground is Andropogon.

leaves which fall year after year gradually produces a humus. The conditions approach more and more those of the typical mesophytic forest, even though xerophytic dune societies may surround on every side. The growth of the humus permits the development of a low vegetation, consisting of lichens, mosses and forest herbs. The vegetation, shade, and humus conserve the water and cause a mesophytic soil in spite of the slope and sand. Seedlings of other trees, yet more indicative of the shady mesophytic forests than the basswood, make their appearance. The most prominent of these is the sugar maple, *Acer saccharinum.* Scarcely less important are the beech, *Fagus ferruginea*, and the hemlock, *Tsuga Canadensis.* These trees produce the densest shade and cause the extermination of the basswood and its associates. Each vegetation from the original Ammophila to the maple forest, therefore, gives a denser shade than the one preceding.

Accompanying the above-named trees are such typical mesophytic forest herbs as *Hepatica triloba*, *Trillium grandiflorum*, *Epiphegus Virginiana*, and *Arisaema triphyllum.* That the conditions not only in the soil but even in the air are less xerophytic than when the basswood was the dominant tree is shown by the great luxuriance of the vegetation. The trees are just as large as in inland forests and the xerophytic structures that were present in the basswoods and their associates are quite absent in the maples, beeches, and hemlocks. The air seems to be almost as mesophytic as in the inland forests. The maple and beech forests are not frequent on old dunes at the south end of the lake, but, for that matter, they are not so well-developed anywhere in this region as they are in Michigan. Mesophytic forests on old dunes were seen at Saugatuck, Grand Haven, Frankfort, and Charlevoix. At Frankfort there is a maple forest on the steep slope of an old dune which is as luxuriantly developed as in an inland location. At Charlevoix a hemlock was seen which had over 200 rings, showing the minimum length of time that the mesophytic flora could have existed on the dune. The mesophytic forest is the most permanent of plant societies

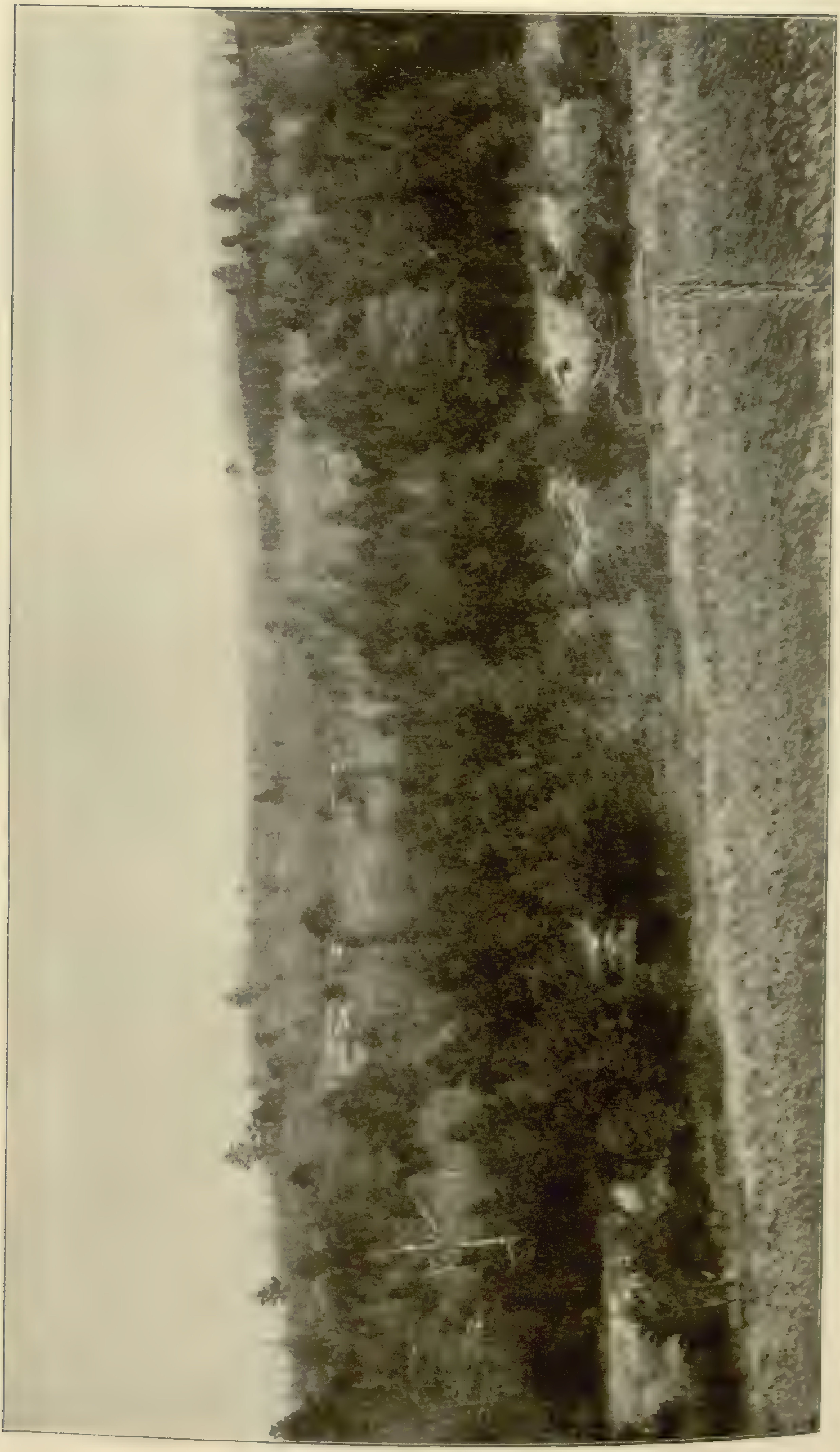

FIG. 20.—North slope of an oak dune at Dune Park, taken in winter, showing scattered pines among the oaks, and an abundance of pines at the lower levels.

in the lake region. It may be regarded as the culmination of the series which began with the lower beach.

2. *The evergreen series.*

a. The heath. — The life-history of a windward slope is vastly different from that which has just been described. If one views a region of established dunes from the lake side, he sees a landscape in which evergreens predominate, whereas a view from the land side often shows a decided dominance of deciduous trees. Not only the windward slopes but the summits have an evergreen flora. The key to these facts is exposure to desiccating factors, especially heat, cold, and winds. So far as the soil is concerned, there is but little difference between the conditions on the windward and leeward slopes. In both cases there is a vegetation carpet and a covering of humus. The more gentle slope favors the retention of moisture, though this factor is counterbalanced by the desiccating influence of the wind on the soil. At the south end of the lake the soil of the leeward slopes is drier than that of the windward slopes, because of the southern exposure and consequent drying influences of the sun. Even in this latter instance, the contrast between the floras of the two slopes is tremendous. It is the condition in the air, not the condition in the soil, which determines the difference here found. Both slopes have a mesophytic soil; the leeward slope also has a mesophytic air, but the windward slope has a xerophytic air.

The heath has several origins but one destiny. It may arise on the slow-growing embryonic dunes, in depressions on the upper beach, on the fossil beach, on gravel terraces, or in pastures. In all cases the dominant plant species come to be ne or more of the following: *Arctostaphylos Uva-ursi, Juniperus mmunis, Juniperus Sabina procumbens.* The first two are common ong the entire coast, the latter only northward. The term heath has been but little used in America, perhaps because we do not have the peculiar Calluna heaths of Europe. The term heath, as here used, may be defined as a xerophytic flora in which there is a dominance of low evergreen shrubs. Warming and Graebner use the term heath much more comprehensively, speaking of moss and lichen heaths and coniferous heaths. Along Lake Michigan the heath formation becomes more and more prominent northward. A well-marked juniper or bearberry heath is rare at the south end of the lake, while extensive areas are covered by the heath on Beaver and North Manitou islands and on the neighboring mainland.

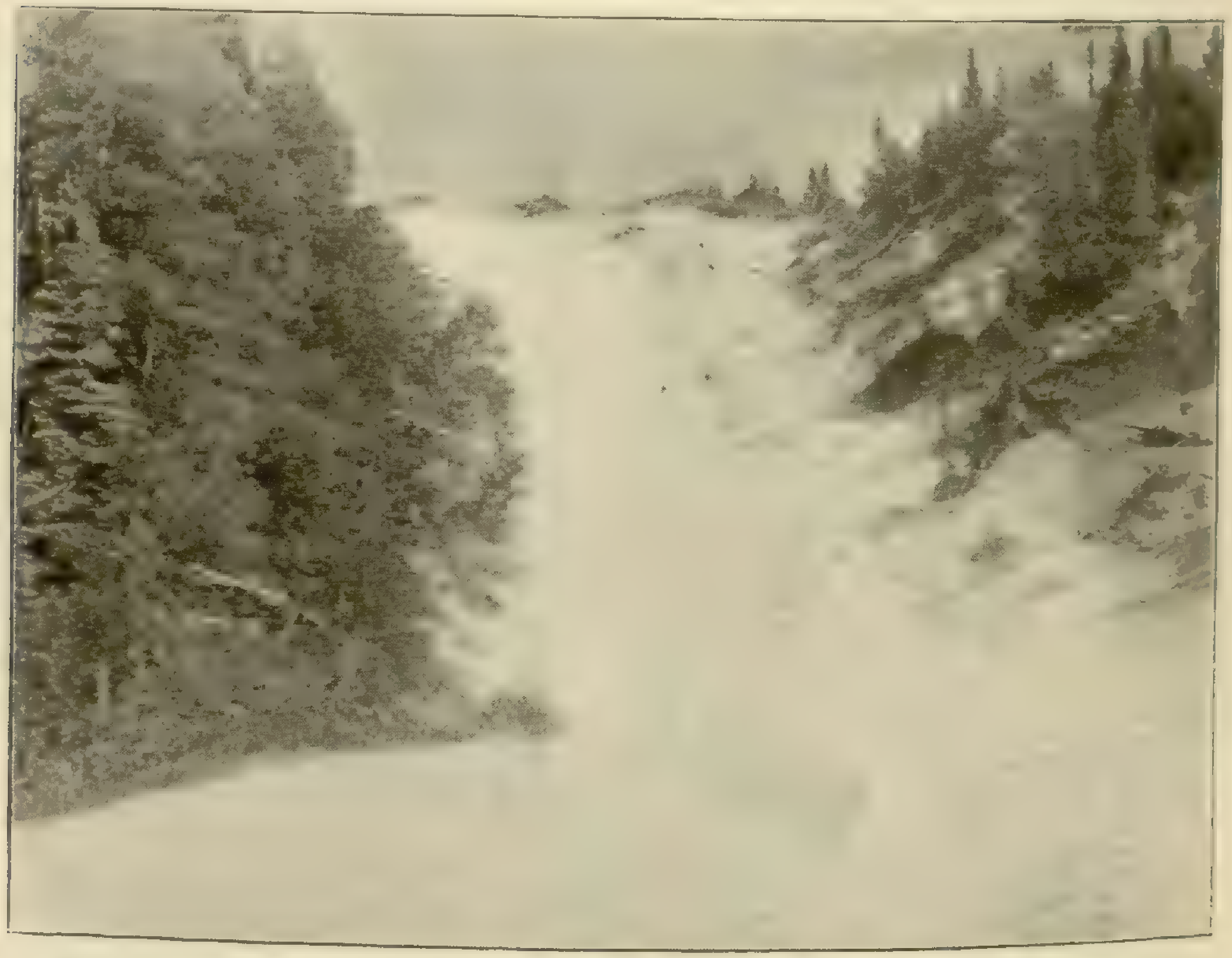

FIG. 21.—Rejuvenated dune on Beaver island. Wind-sweep at the center. Coniferous forests on each side that are not yet destroyed.

During the development of a heath, the vegetation partakes of the nature of the formation which preceded it, whether dune or beach or terrace. Before the true heath plants cover the soil, the open places are inhabited more or less abundantly by such plants as *Prunus pumila*, *Salix glaucophylla* and *adenophylla*, *Solidago humilis Gillmani* and *nemoralis*, *Aster laevis*, *Calamagrostis longifolia*, *Smilacina stellata*, *Lithospermum hirtum*, *Artemisia Canadensis*, *Rhus Toxicodendron*, *Rosa Engelmanni*. On fossil beaches and terraces, embryonic heaths often have *Hudsonia tomentosa*, *Andropogon scoparius*, and *Campanula rotundifolia arctica* in addition to the above.

At the center of *fig. 6* there is shown a heath developing on a substratum of embryonic dunes; the bearberry has already covered a large portion of this area with a low heath carpet. *Fig. 24* shows the development of a heath on a fossil beach. In the foreground is a typical fossil beach flora, consisting of scattered grasses, sand cherries, etc. The small scattered tufts are Hudsonia. At the center is a low Ammophila dune, while back of this are patches of embryonic heath, composed of the bearberry and the procumbent juniper. Along the edge of the forest the heath forms a continuous carpet. *Fig. 25* shows a typical juniper heath when fully developed. At the left background the heath is younger and still made up of disconnected patches. *Fig. 26* shows the formation of a *Juniperus communis* heath in a pasture. Since this latter species is more or less erect, while the bearberry and procumbent juniper are creepers, the aspect of the heath shown in *fig. 26* is very different from those shown in *figs. 6* and *24*.

b. The coniferous forests.—Whatever the origin of the heath, it is rarely a climax type along the Lake Michigan shore. It almost uniformly develops into a coniferous forest sooner or later. The most conspicuous and extensive forests of this type are on the lakeward slopes, at the summit of these slopes, or at the summit of the taller inland dunes. These forests, like the heath, become more abundant and the growth more luxuriant as one passes northward along the lake shore.

The development of a forest from a heath is easy to understand and can be observed at almost all points. The heath vegetation is dense enough to prevent the tearing up of the soil by the wind, but not too dense for seedlings of various trees to get a start. The dense tangle of junipers and bearberries close to the soil is peculiarly well fitted to protect the trees while small and tender. In a very short time small and scattered trees become conspicuous on the heath. The transformation of a

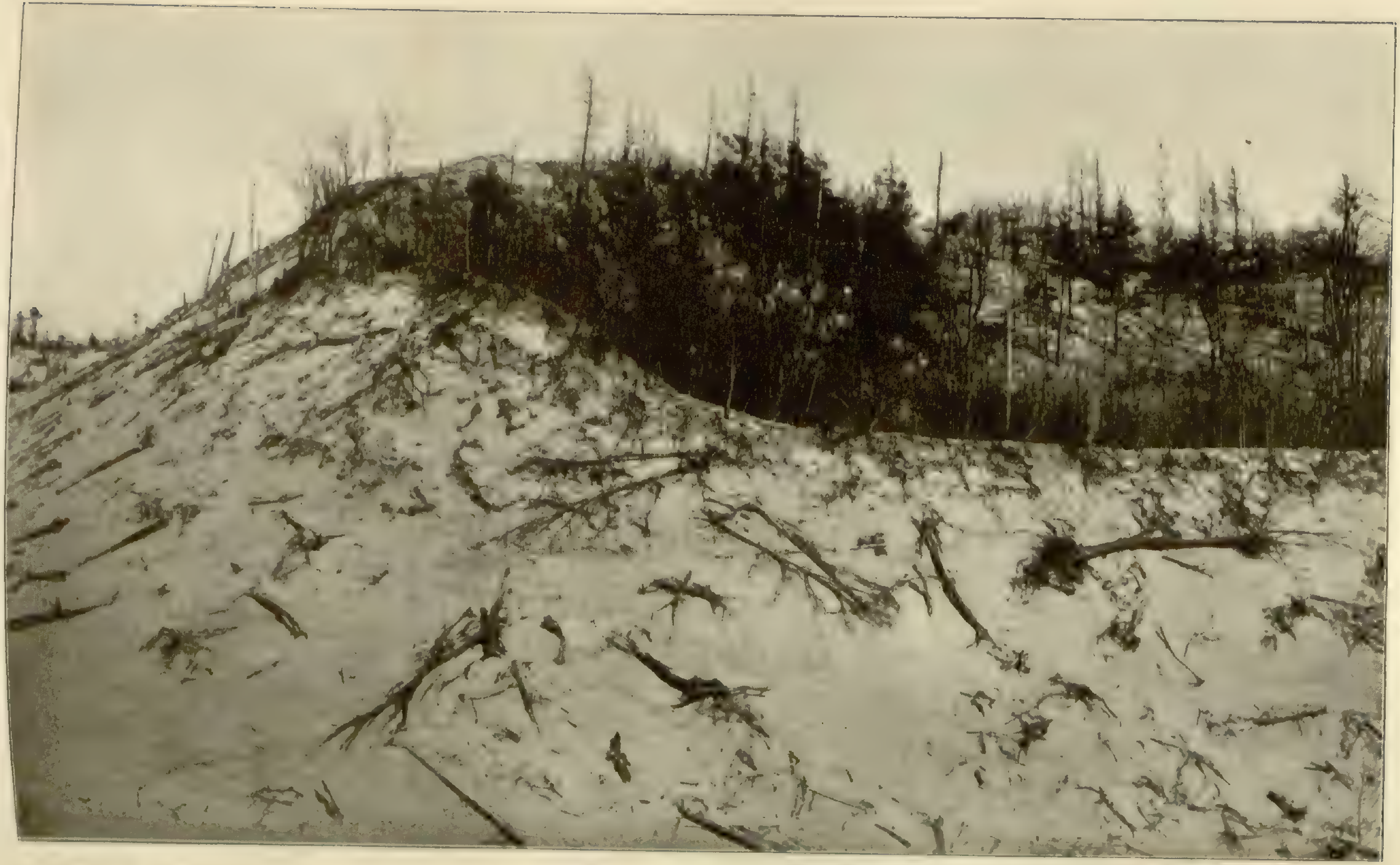

FIG. 22. Crateriform depression at Dune Park, within which are basswoods and pines in a state of considerable luxuriance. The slope in the foreground is the side of a deep wind-sweep; the development of this wind-sweep brings about the destruction of the flora through the action of gravity.

heath into a forest is illustrated by *figs. 24* and *25*. In each case the heath is encroaching on a beach and is being followed up *pari passu* by the forest. The advance of the heath is secured mainly by vegetative propagation, that of the forest by germination of seeds. This fact, together with the need for protection to the seedlings, prevents the forest from overtaking the heath in the struggle for more territory. So far as observed, the heath always precedes the forest, when the latter is developed in an exposed situation.

In the region as a whole, the pines are by all odds the character trees of the coniferous forests, and especially the white pine, *Pinus Strobus*. This tree is found at all places along the coast. At the south end of the lake the scrub pine, *Pinus Banksiana*, is more abundant than the white pine, while at the north end the red pine, *Pinus resinosa*, is often as frequent as the white pine. The distribution of the pines is very surprising. The scrub pine is the most northern of the three pines mentioned, and its farthest known southern limit is about the south end of Lake Michigan. Peculiarly enough, it is far more abundant than all other conifers put together at the south end of the lake, while it is much less abundant to the north along the lake shore. It was not seen at all north of Glen Haven, though it is reported as common inland. The red and white pines have in general a more southern range than the scrub pine, and yet they are more abundant northward along the lake than is the latter. Furthermore, these pines become more abundant absolutely as one goes northward. The red pine was not seen south of Pentwater.

North of Grand Haven *Thuya occidentalis* becomes a frequent member of the coniferous forests; sometimes it becomes as dominant as the pines. The same may be said of *Abies balsamea*, though it was not seen south of Frankfort. *Juniperus Virginiana* is frequent, especially southward. With the evergreens are occasional deciduous trees, especially at protected forest margins; among these are *Betula papyrifera*, *Tilia Americana*, *Populus monilifera*, and *Ostrya Virginica*.

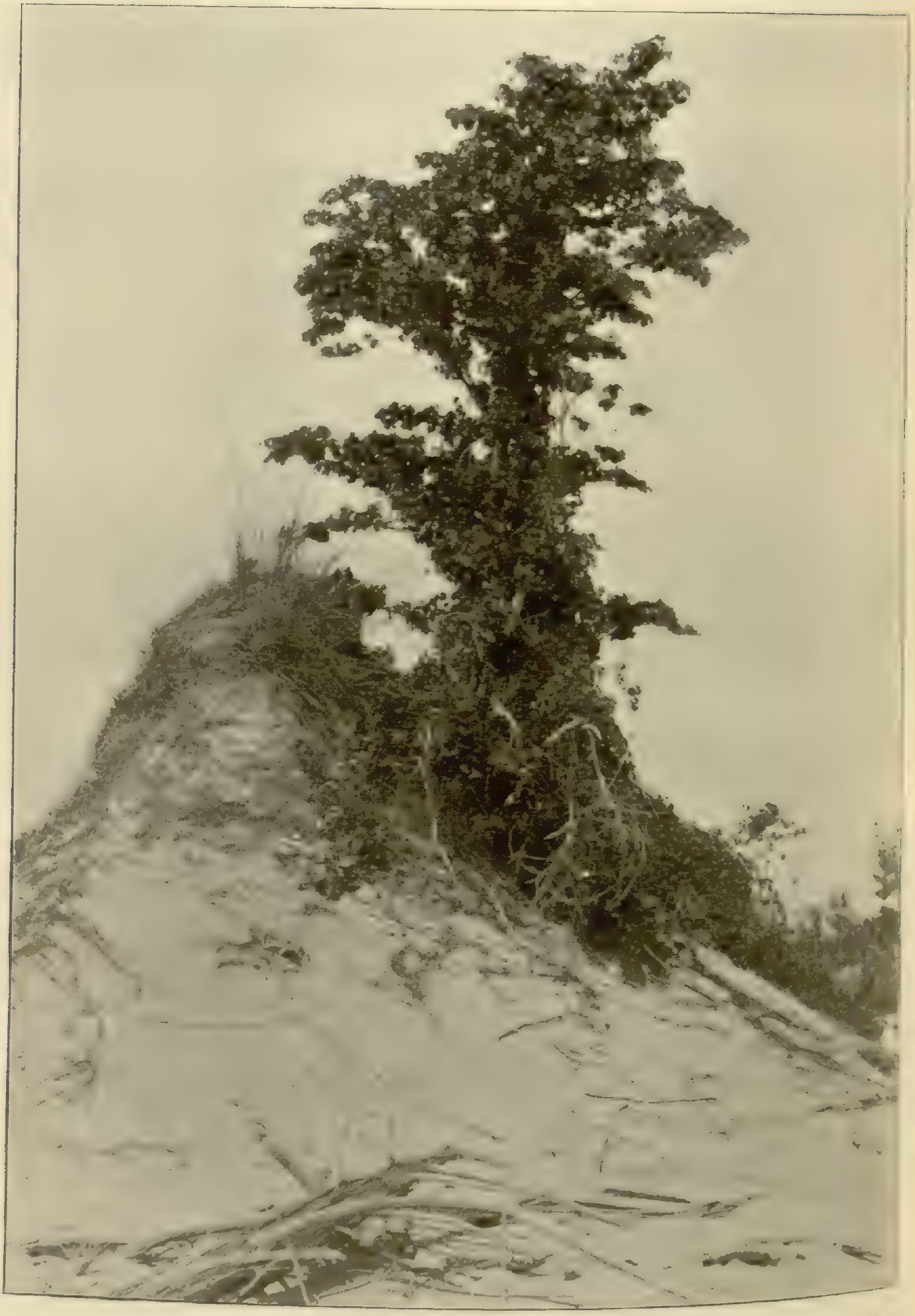

FIG. 23.—Rejuvenated dune at Dune Park. The basswood is the last remnant of a former forest. Clump of Calamagrostis at the left, showing the tenacity with which its roots hold the sand.

So long as the coniferous forests remain more or less open, the three dominant heath plants, *Arctostaphylos Uva-ursi*, *Juniperus communis*, and *J. Sabina procumbens*, retain their prominence. Of these Arctostaphylos is the most persistent, and may be regarded as the most characteristic plant of the forest undergrowth. There are occasional shrubs in the open places, such as *Shepherdia Canadensis*, *Diervilla trifida*, *Rosa Engelmanni*, *Prunus pumila*. Among the herbs in open places are *Calamagrostis longifolia*, *Aster laevis*, *Smilacina stellata*, *Arabis lyrata*, *Lithospermum hirtum*. Many mosses occur more or less shaded by the evergreens, especially Thuidium and other trailing varieties. *Fig. 19* shows a coniferous society at the summit of a dune. The trees are white pines; the shrubs in front of them, *Juniperus communis;* those at the left, *J. Virginiana*. The grass in the foreground is *Andropogon scoparius*. Coniferous forests on exposed slopes are shown in *figs. 6* and *21*.

The coniferous forests heretofore considered are chiefly on exposed slopes and summits. Sometimes there are coniferous forests farther inland developed on older and lower dunes. The protection here is greater and the air is less xerophytic. Extensive forests of this type were found between Frankfort and Empire and on Beaver island. The trees are chiefly pines or balsams just as before, but the evergreen undergrowth of junipers and bearberries is largely replaced by such plants as *Vaccinium Pennsylvanicum*, *V. Canadense*, *Epigaea repens*, *Gaultheria procumbens*, *Linnaea borealis*, *Melampyrum Americanum*, *Pteris aquilina*. In the more open and sterile places there is often a moss or lichen carpet, consisting largely of *Cladonia rangiferina* (or other Cladonia species) or *Polytrichum commune*. At the south end of the lake plant societies of this type become more like pine barrens. On the east coast of Beaver island there is a beautiful gradation series from the heath on the beach through a pine forest like that described in this paragraph into a pine forest in which there is almost no undergrowth at all. The scarcity of herbaceous or shrub vegetation is due to the dense shade and the carpet of pine needles. This last type is the summit of the evergreen series, and is in all probability a climax type, at least in certain situations.

A very distinct type of coniferous forest is especially well developed at the south end of the lake. Since it is not developed in exposed situations, or even on old dunes, but in low depressions between dunes, it may be called a pine bottom. These societies are developed where the soil is almost hydrophytic. A common location for these miniature pine forests is about the gently sloping margin of an undrained swamp. *Figs. 9, 13, 14*, and *20* show them in such a situation. The line of demarcation between the sedge swamp and the pines is usually quite sharp. The surface of the soil where the pines grow may be less than a meter above the water level.

The character tree of the pine bottoms is always *Pinus Banksiana*. This species is, perhaps, less common than the white pine at the higher levels, but the white pine is rarely, if ever, present on the bottoms. No growth of trees anywhere in the dune region is so pure as the pine growth here. The most common shrubs in these locations are *Hypericum Kalmianum*, *Salix glaucophylla*, *Arctostaphylos Uva-ursi*, and *Juniperus communis*. *Linnaea borealis*, *Arabis lyrata*, *Fragaria Virginiana*, and species of Pyrola are frequent. The development of the pine bottom floras was seen at several points. One of the most interesting cases was in a region of oak dunes, where a railroad company had removed considerable sand and lowered the level several meters. Although surrounded on all sides by oaks and at some distance from a pine flora, the new flora at the lower level is developing into that of a pine bottom.

c. The rejuvenated dunes.—The instability of dune conditions is not confined to the dune-complex. The capture or establishment of a dune is liable to be stopped at any point and retrogression toward the active dune conditions instituted. Even a dune that has long been completely established may have its vegetation destroyed and pass again into a state of activity. This process may be called rejuvenation. Any dune may become rejuvenated if the physical conditions are favorable, but the great majority of rejuvenated dunes are developed from established coniferous dunes; hence this type is discussed in connection with the evergreen series. The coniferous forests that develop on the windward slopes near the lake are peculiarly subject to destruction. The slightest change in the physical conditions is often sufficient to bring about the destruction of a coniferous society. The removal of a comparatively slight barrier may be enough to direct the entire wind energy against a pine forest.

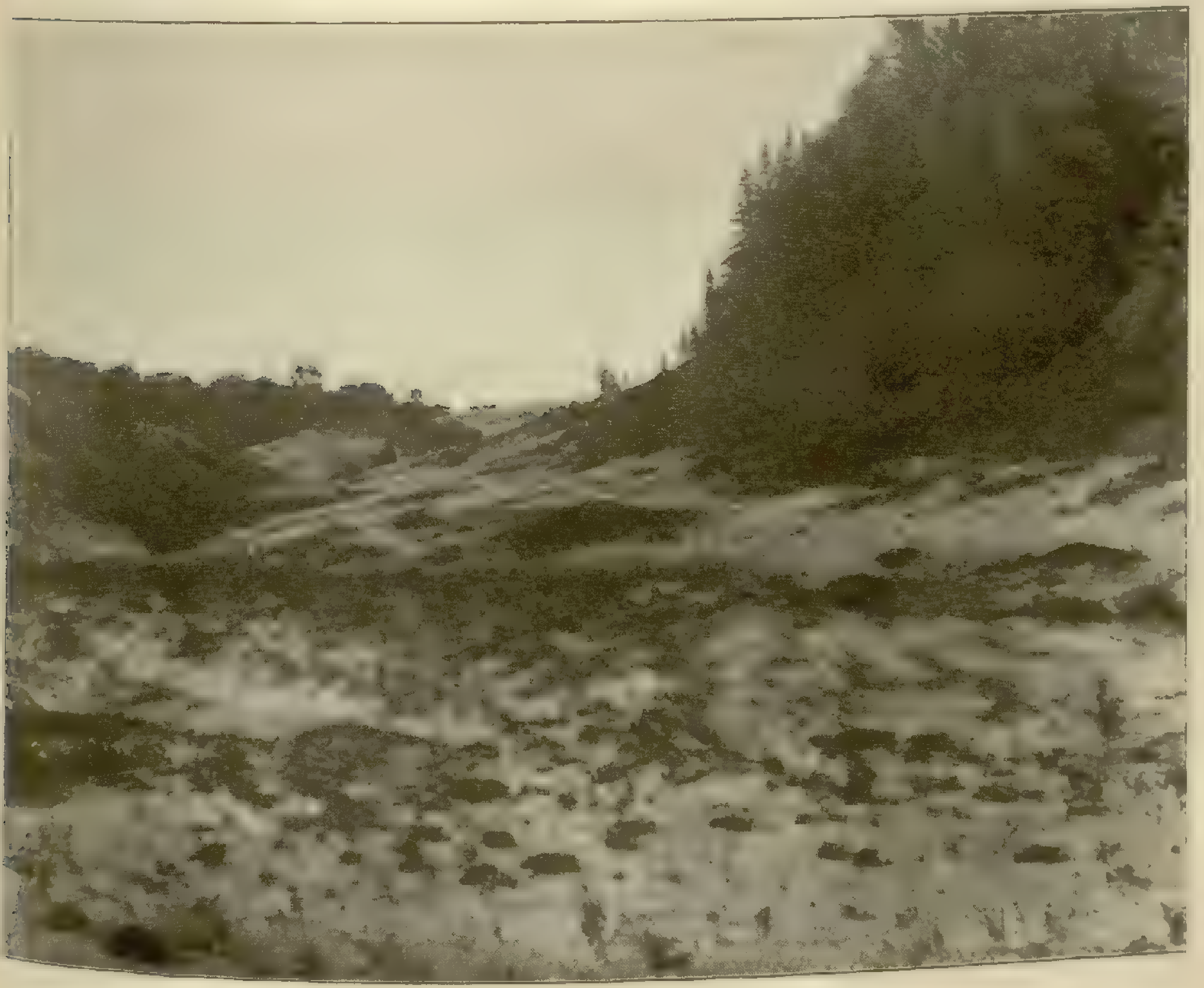

FIG. 24.—Beginnings of a heath on a fossil beach at North Manitou island. Grasses, sand cherries, and patches of Hudsonia in the foreground. Low Ammophila dune at the center. Patches of bearberry heath forming farther back. Advance of the coniferous forest out upon the heath.

The formation of a wind-sweep is, perhaps, the most common way for rejuvenation to begin. *Fig. 6* shows a windward slope tenanted by conifers that has become rejuvenated at three points. One of these wind-sweeps is seen at closer range in *fig. 21*. This latter sweep is forty-five meters in height, and the angle of slope varies from twenty to thirty degrees. When once a sweep is formed the tendency to self-perpetuation becomes greater and greater, since the wind becomes more and more concentrated as the sweep grows deeper. The destruction of the forest vegetation is very soon accomplished at such a place. The desiccating influence of the wind becomes increased and makes it difficult even for the xerophytic conifers to survive. At no place is the destructive action of the sand-blast seen so well as in these rejuvenated sweeps. The branches and even the trunks of the trees have the softer parts carved away, while the more resistant portions stand out in conspicuous relief. The leaves, especially of deciduous trees, are torn or withered or even altogether destroyed.

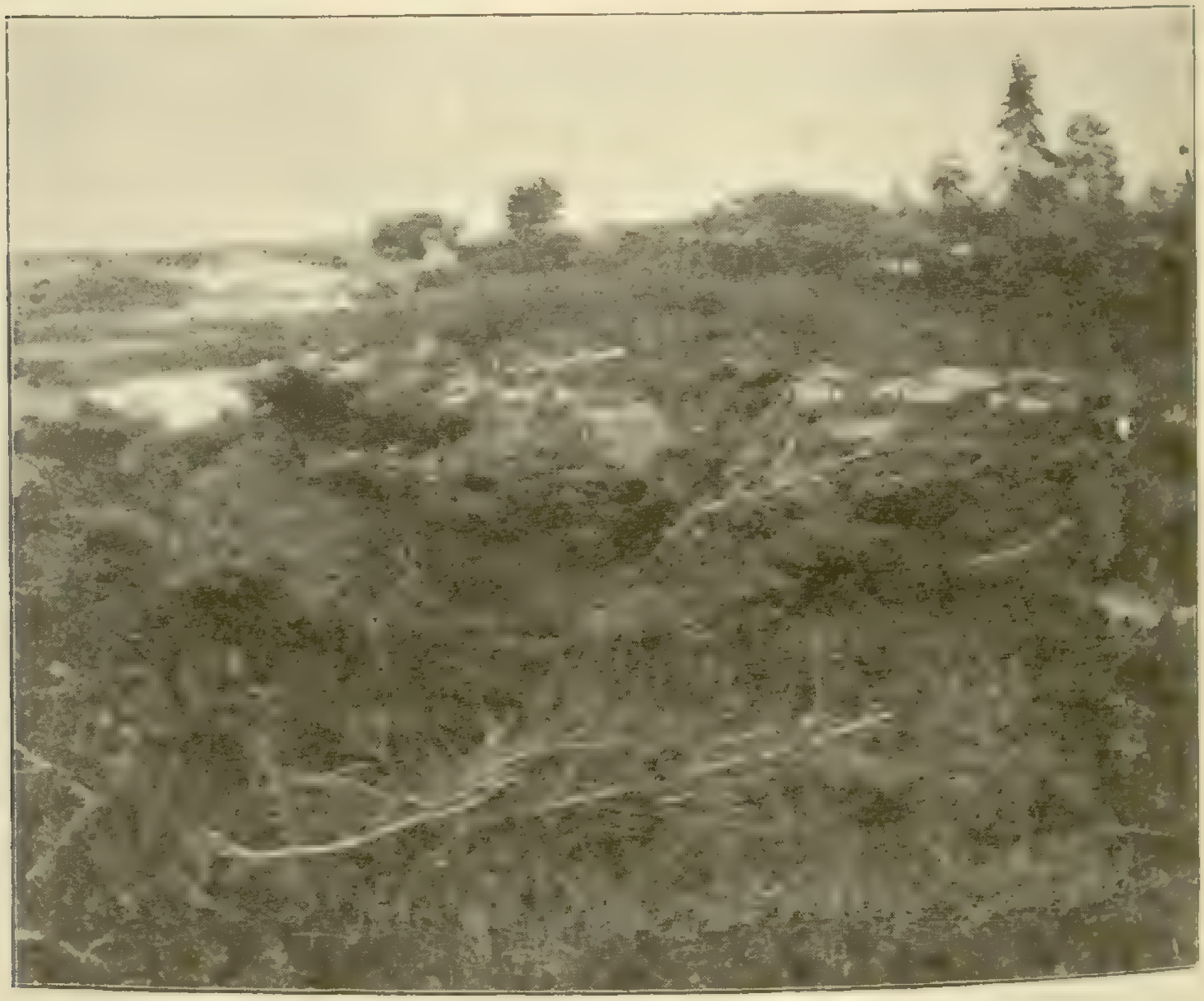

FIG. 25.—Juniper heath on North Manitou island. Young heath patches at the left background. Fully developed heath in the foreground. Advancing coniferous forest at the right background.

These destructive agencies are aided by another force that is altogether irresistible when the sweeps grow deeper, the force of gravity. *Fig. 22* shows a plant society that is being destroyed mainly by gravity. The view is taken looking at the side of a deep gorge-like wind-sweep which the wind has cut. As the wind blows along, its energy increased by concentration, a large amount of sand is picked up along the base of the steep sides. The sand is as steep as it will lie, so that each removal causes a movement of the sand down the slope. The fallen trees shown in the photograph have been overturned and carried down the slope in just this way. That the direct action of the wind is also powerful enough to destroy without the assistance of gravity is proven by the dead but standing trees at the left, where the action of gravity happens to be much less.

Many plant species resist the process of dune rejuvenation to a surprisingly successful extent. *Fig. 23* shows the last remnant of a plant society that may have been somewhat extensive. The tree at the center is a basswood, a tree which could never develop in such an exposed situation. In all probability this mound is a fragment of a protected lee slope, on which the basswood grew and flourished for a time. The grass at the left is Calamagrostis; the tenacity with which it holds its ground has already been mentioned. Sometimes a group of cedars, *Juniperus Virginiana*, remain at the apex of a conical mound of sand, their associates having been swept away with the sand in which they grew. On the beach at Charlevoix there is a stranded clump of stunted trees of Thuya; they are probably the remnant of a society which has been otherwise destroyed.

As a wind-sweep is developed, and the evergreen vegetation destroyed, many plants that have been previously mentioned as characteristic of bare and exposed situations again make their appearance. The most prominent of these are *Artemisia Canadensis* (or *A. caudata*), *Elymus Canadensis*, *Solidago humilis Gillmani*, *Asclepias Cornuti*, *Œnothera biennis*, *Rosa Engelmanni*, *Calamagrostis longifolia*, *Prunus Virginiana*. In addition to these there come in, of course, the annuals and biennials mentioned in connection with the wind-sweeps on the dune-complex.

While rejuvenated dunes are to be found along the entire coast, they reach their highest development northward, especially at the summit of the terraces and bluffs. Perched dunes, it would seem, are favorably located for destruction by the wind. At Frankfort and Empire the perched dunes are in the earlier stages of rejuvenation. At Glen Haven these dunes have been rejuvenated, the vegetation entirely destroyed, and the sand removed inland to form the gigantic moving dunes previously mentioned. The substratum on which the dunes rested remains as a bare gravel mesa, with only the Sleeping Bear left to tell the tale of its former occupation by coniferous dunes. It is barely possible that some of these so-called rejuvenated dunes have never been established, and that they have grown slowly to their present height *pari passu* with the vegetation. This is purely a theory without any facts whatever to support it. The evidence seems to point unmistakably to an establishment followed by

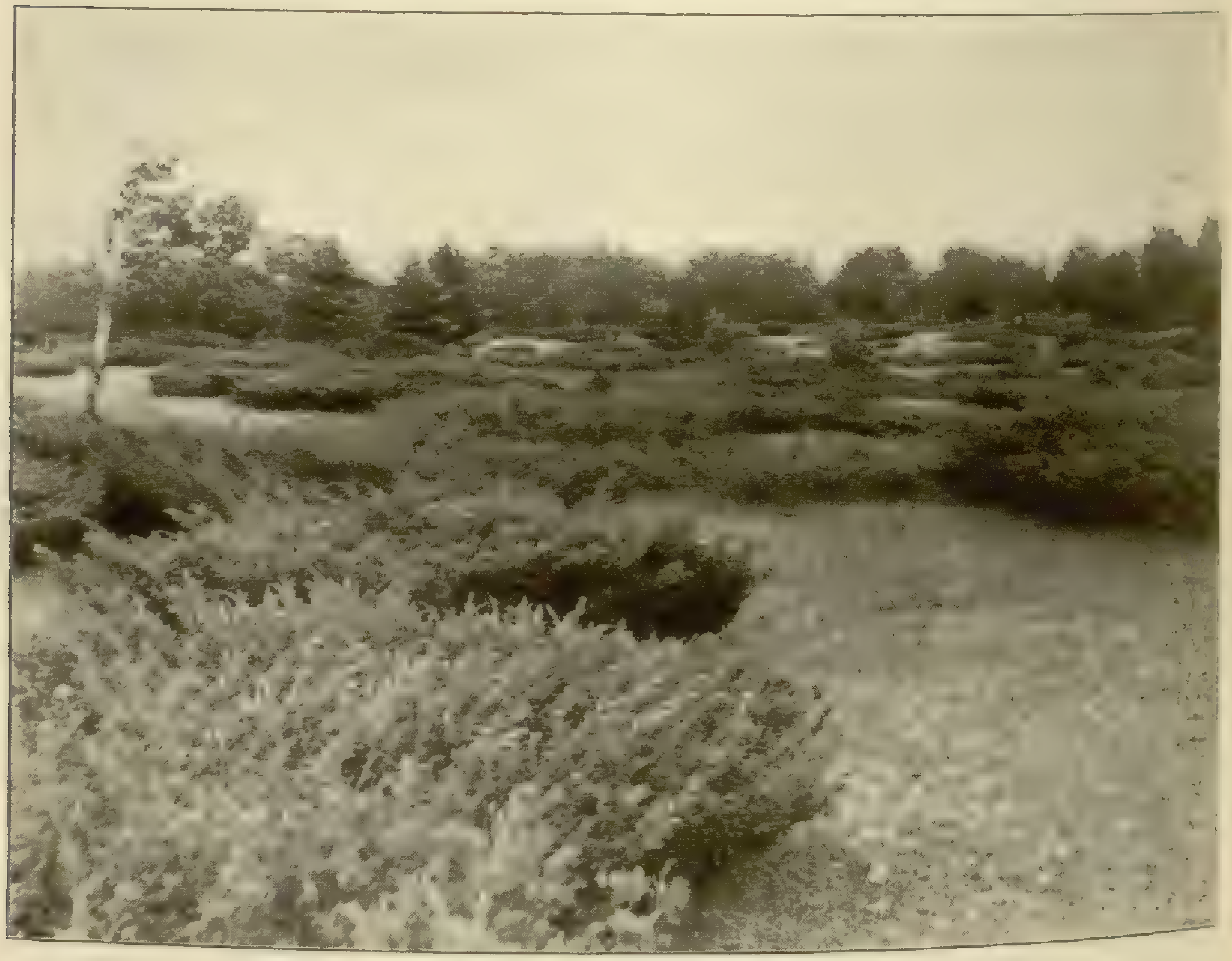

FIG. 26.—Development of a juniper heath in a pasture at Beaver island.

rejuvenation. Evergreen vegetation is very poorly adapted for any *pari passu* growth, such as is found on the embryonic dunes.

3. *The oak dunes.*

At the south end of the lake, and as far up the eastern shore as Manistee, there may be seen old dunes covered over with rather open and scrubby oak forests. These dunes have long been established and are entirely free from the destructive sand-laden winds which are so influential in determining the character of the other dune societies. As a rule the oak dunes are low and are separated from the lake by several series of dunes on which the vegetation is less stable.

The dominant tree on the oak dunes is the black oak, *Quercus coccinea tinctoria.*[5] This tree is far more abundant than all others combined. The only other tree that may be called characteristic in the Dune Park region is *Quercus alba.* On some oak dunes there are low trees or tall shrubs of *Sassafras officinale, Cornus florida, Amelanchier Canadensis,* and *Hamamelis Virginiana.* The characteristic shrubs are comparatively few except along the lower margins toward the swamp level, or on shaded northern slopes. The most abundant shrubs are *Vaccinium vacillans* and *V. Pennsylvanicum, Salix humilis, Viburnum acerifolium, Rosa blanda* and *R. humilis,* and *Rhus copallina.*

The herbaceous vegetation of the oak dunes is very diversified and interesting. The trees are always far enough apart to permit an extensive undergrowth of relatively light-loving plants. On the southern slopes, where there is considerable exposure to the sun, there is rarely a continuous vegetation carpet, but a more or less tufted vegetation with intervening patches of naked sand. A large number of herbs are characteristic of such places, for example: *Pteris aquilina, Koeleria cristata, Cyperus Schweinitzii, Carex Pennsylvanica, C. umbellata, C. Muhlenbergii, Tradescantia Virginica, Arabis lyrata, Lupinus perennis, Tephrosia Virginiana, Les-*

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[5] The closely related *Quercus rubra* and *Q. coccinea* occur commonly in neighboring plant societies and may be present on the dunes, as may hybrids between any of the three forms here mentioned.

pedeza capitata, *Euphorbia corollata*, *Helianthemum Canadense*, *Viola pedata*, *Opuntia Rafinesquii*, *Œnothera rhombipetala*, *Monarda punctata*, *Aster linariifolius*, *Helianthus divaricatus*. In very open places there are various species of Geaster and Lycoperdon. *Festuca tenella*, *Polygonum tenue*, *Polygonella articulata*, *Talinum teretifolium*, *Mollugo verticillata*, *Draba Caroliniana*, *Linaria Canadensis*, *Krigia Virginica*.

On the shaded northern slopes *Pinus Banksiana* and *Pinus Strobus* often occur with the oaks (see *fig. 20*). The undergrowth is often a complete vegetation carpet, and consists of Vaccinium, Viburnum, and others of the above plants, together with many different forms. Among the plants here there may be mentioned various species of Cladonia and Peltigera, several mosses, *Aquilegia Canadensis*, *Epigaea repens*, *Phlox pilosa*.

In the background of *fig. 9* there may be seen several oak dunes. The view was taken in the winter and shows a dominance of oaks, but the scrub pines are scattered here and there on northern slopes or in exposed situations. *Fig. 11* shows the advance of an active dune on the north slope of an oak dune with a wealth of oaks and a few scattered pines. *Fig. 20* is a view looking upon the north slope of an oak dune (taken in winter). The pines are abundant at the base and scattered on the slope. A view of the south slope would show no pines at all.

The conditions for the origin and development of an oak dune flora are obscure. At Grand Haven and Ludington the oak flora appears to follow the basswood flora. Remnants of the basswood flora are conspicuous in both places: Sassafras, Hamamelis, Vitis, Smilacina, *Rhus Toxicodendron*, Smilax, Celastrus. It may be that where the conditions are most favorable a maple forest develops after the basswood, but the oak forest elsewhere. At any rate the maple forests are more prevalent northward and the oak forests southward. While the oak forests at Grand Haven, Ludington, and Manistee are on steep, long-established lee slopes, the oak forests at the south end of the lake are often on rather low ridges, where the basswood may never have prevailed.

Quite probably the pine is the normal predecessor of the oak. The scattered pine trees shown in *figs. 9* and *20* may be the relicts of a more extensive pine flora that has been succeeded by the oaks. The oak cannot get a foothold until the dune has become well established and protected from the lake winds. If the pines are scattered, there is opportunity for the oak seedlings to develop successfully. Forest fires are more destructive to the pines than to the oaks; the former are more readily burned, and basal sprouts are less likely to appear afterward than in the case of the oaks. Near Dune Park there is a tract on which the pines have been burned and replaced by the oaks.

One of the most striking landscape features of the Dune Park region is the appearance of the pines at the lower levels (pine bottoms), and again on the highest summits. The oaks occupy an intermediate position as to altitude. The reason for this distribution seems to be that the pines have a much wider range of life conditions than the oaks. The oaks are excluded from the summits because of the extreme exposure to wind and cold; they are not xerophytic enough for such a habitat. They are excluded from the bottoms, because the conditions are too hydrophytic for them there. The pines are excluded from the intermediate positions not because of lack of adaptation, but because the oaks are better adapted for that position than are the pines. Where the oaks can live at all, they seem able to drive out the pines, while the pines occupy areas that are not adapted to the oaks.

The flora of the oak dunes, especially that found on sunny southern slopes, is a true xerophytic flora, but a xerophytic flora resembling that of the more southern type, where the adaptations are developed to protect against heat and the excessive transpiration which it causes. The flora on northern and windward slopes is predominantly evergreen, developing into a heath or a coniferous forest. This flora, too, is xerophytic, but of an arctic or alpine type, where the adaptations are developed to protect against the wind and cold and the dangers of excessive transpiration which they bring. The correctness of this view is shown by studying the floras of the oak and pine dunes. The former has a flora related to those farther south, containing Opuntia, Euphorbia, and many other plants of southern range. The pine dunes, on the other hand, show the farthest southern limits of many northern plants—for example, the scrub pine itself. Linnaea, the bearberry, and many others have a northern range.

V. Conclusion.

No attempt will be made to summarize the results of this study, but a few of the more striking phenomena of the Lake Michigan dunes and their vegetation will be given. The dunes have been determined in the main by westerly winds. The great majority of the dunes are established, and many of them are perched high up on bluffs. The vegetation is xerophytic, belonging either to the arctic or desert type.

The xerophytic beaches are subdivided into three zones: the lower beach which is washed by summer waves and is essentially devoid of life; the middle beach which is washed by winter waves and is inhabited only by succulent annuals; the upper beach which is beyond present wave action and is inhabited also by biennials and perennials. There are also fossil beaches and gravel terraces with a flora resembling that of the upper beach, but less xerophytic.

Perennial plants are necessary for any extensive dune formation on the beach, since they alone furnish growing obstacles. Such plants must be pronounced xerophytes and be able to endure covering or uncovering. The most successful dune-formers are *Ammophila arundinacea*, *Agropyrum dasystachyum*, *Elymus Canadensis*, *Salix glaucophylla* and *S. adenophylla*, *Prunus pumila*, *Populus monilifera*. Ammophila and Agropyrum form low dunes that have a large area, because of their extensive rhizome propagation. The Elymus dunes do not increase in area since rhizome propagation is absent. The Salix dunes increase both in area and height, because of extensive horizontal and vertical growth. The Populus dunes are the highest and steepest, since the cottonwoods grow quite tall, but do not spread horizontally.

Small dunes are formed in more protected places by plants that are unable to exist on the beach, or where there is rapid dune formation. Among these secondary dune-formers are Andropogon, Arctostaphylos, Juniperus. Primary embryonic dunes may pass gradually into this second type, as this latter passes into the heath.

The stationary embryonic dunes on the beach begin to wander as soon as the conditions become too severe for the dune-forming plants. The first result of this change is seen in the reshaping of the dune to correspond with the contour of a purely wind-made form. The rapidity of this process is largely determined by the success or failure of the dune-formers as dune-holders. The best dune-holders are Calamagrostis, Ammophila, and Prunus.

There are all gradations between a simple moving dune and a moving landscape; the latter may be called a dune-complex. The complex is a restless maze, advancing as a whole in one direction, but with individual portions advancing in all directions. It shows all stages of dune development and is forever changing. The windward slopes are gentle and are furrowed by the wind, as it sweeps along; the lee slopes are much steeper. The only plant that flourishes everywhere on the complex is the succulent annual, *Corispermum hyssopifolium*, although *Populus monilifera* is frequent. The scanty flora is not due to the lack of water in the soil, but to the instability of the soil and to the xerophytic air.

The influence of an encroaching dune upon a preexisting flora varies with the rate of advance, the height of the dune above the country on which it encroaches, and the nature of the vegetation. The burial of forests is a common phenomenon. The dominant forest trees in the path of advancing dunes are *Pinus Banksiana*, *Quercus coccinea tinctoria*, and *Acer saccharinum*. of these trees are destroyed long before they are completely buried. The dead trees may be uncovered later, as the dune passes on beyond.

In the Dune Park region there are a number of swamps upon which dunes are advancing. While most of the vegetation is destroyed at once, *Salix glaucophylla*, *S. adenophylla*, and *Cornus stolonifera* are able to adapt themselves to the new conditions, by elongating their stems and sending out roots from the buried portions. Thus hydrophytic shrubs are better able to meet the dune's advance successfully than any other plants. The water relations of these plants, however, are not rapidly altered in the new conditions. It may be, too, that these shrubs have adapted themselves to an essentially xerophytic life through living in undrained swamps. Again it may be true that inhabitants of undrained swamps are better able to withstand a partial burial than are other plants.

Vegetation appears to be unable to capture a rapidly moving dune. While many plants can grow even on rapidly advancing slopes, they do not succeed in stopping the dune. The movement of a dune is checked chiefly by a decrease in the available wind energy, due to increasing distance from the lake or to barriers. A slowly advancing slope is soon captured by plants, because they have a power of vertical growth greater than the vertical component of advance. Vegetation commonly gets its first foothold at the base of lee slopes about the outer margin of the complex, because of soil moisture and protection from the wind. The plants tend to creep up the slopes by vegetative propagation. Antecedent and subsequent vegetation work together toward the common end. Where there is no antecedent vegetation, Ammophila and other herbs first appear, and then a dense shrub growth of Cornus, Salix, *Vitis cordifolia*, and *Prunus Virginiana*. Capture may also begin within the complex, especially in protected depressions, where *Salix longifolia* is often abundant.

Tilia Americana develops rapidly on the captured lee slopes, and the thicket is transformed into a forest. The trees grow densely, and there is little or no vegetation carpet. Associated with Tilia is a remarkable collection of river bottom plants, so that the flora as a whole has a decided mesophytic cast. These plants have developed xerophytic structures that are not present in the river bottoms. Acer and Fagus succeed Tilia and represent the normal climax type of the lake region, the deciduous forest.

On the established windward slopes the development is quite different from that described above. There is a dominance of evergreens instead of deciduous vegetation. The soil conditions are nearly alike on the two slopes, but the air is more xerophytic on the windward slopes. The evergreen flora starts as a heath formed of Arctostaphylos, *Juniperus communis*, and *J. Sabina procumbens*. The heath arises on fossil beaches, secondary embryonic dunes, or wherever the wind is relatively inactive and where the conditions are too xerophytic for the development of a deciduous flora. Before long the heath passes into a coniferous forest, in which *Pinus Banksiana*, *P. Strobus*, or *P. resinosa* dominate. Coniferous forests also occur on sterile barrens and in bottoms, where the conditions are also unfavorable for deciduous forests. A slight change in the physical conditions may bring about the rejuvenation of the coniferous dunes, because of their exposed situation. Rejuvenation commonly begins by the formation of a wind-sweep; the vegetation on either hand is forced to succumb to sand-blast action and gravity.

The evergreen floras are more and more common northward, while to the south there are developed forests in which *Quercus coccinea tinctoria* prevails. The oak forests are more common on inland dunes and on southern slopes. The oaks may follow the pines, when the areas occupied by pines become sufficiently protected from cold winds. The pines have a much wider range of life conditions than the oaks, since they appear at lower levels, higher levels, and on northern or windward slopes. The oaks flourish best on southern slopes. The flora of the oak dunes is xerophytic, but of the desert type, while that of the pine dunes is of the arctic xerophytic type. The pine dunes have a northern flora, the oak dunes a southern flora.

VI. Previous studies of sand dune floras.

A great deal of physiographic work has been done in sand dune areas in total disregard of the plant life, although the results obtained from this study show that the vegetation profoundly modifies the topography. In like manner the flora has often been studied from a purely taxonomic standpoint, little attention being paid to the striking effects of the environment upon plant structures. More recently the ecological standpoint has been taken by a number of investigators, particularly to show the influence of the extreme environment upon plant organs and tissues. The second part of this paper will treat this phase of the subject in some detail. Very little previous work has been done on the geographic phase of the subject from the standpoint of historical development and the order of genetic succession of the various dune types. Still less has there been any adequate study of the modifying influence of vegetation upon topography. These latter phases of the subject have given color to the work which has resulted in this paper.

Warming's work on the sand dune vegetation of Denmark stands in the front rank. In his separate publications and in his text-book of ecology, the conditions on the Danish dunes are quite fully stated. The order of succession, speaking broadly, seems to be quite similar to that along Lake Michigan, but there appears to be less diversity of conditions, and the features appear to be developed on a smaller scale. The strand is succeeded by the wandering or white dunes, and these by the established or gray dunes. Beyond these are sandy fields. Just as along Lake Michigan, the dune floras may pass into the heath and these latter into coniferous forests.

There is a remarkable similarity in the flora of the Danish and Lake Michigan dunes. The same genera and often the same species occur in the two regions. *Cakile maritima* and *Lathyrus maritimus* grow on the strand. *Ammophila arundinacea* (=*Psamma arenaria*), *Elymus arenarius*, and *Agropyrum junceum* grow on the wandering dunes. Where the genera are not common or even nearly related, there are to be found in the two regions plants that have the same life habits. There is thus a striking similarity in the two regions in almost every respect, and that too in spite of the marine conditions in Denmark, as contrasted with the inland fresh-water area in the United States. The life conditions appear to be essentially alike on all dunes, whether marine or not, and there are found not only identical life habits, but even identical plant species.

Warming reports Chlamydomonas on the strand in the same relations as along Lake Michigan. Among the sand-binding plants, Warming and Graebner give an important place to mosses. Along the Lake Michigan dunes, mosses do not appear to any great extent until establishment is nearly complete. On the Denmark coast, the Agropyrum dunes are lower than those formed by Ammophila, just as along Lake Michigan. The Danish dunes have also been studied by Raunkiaer, Paulsen, and Feilberg. Erikson has studied the similar dunes of southern Sweden, Giltay and Massart those of Holland and Belgium.

The dunes on the islands along the German coast have been carefully studied by Buchenau and to some extent by Knuth. Graebner, in his exhaustive work on the North German heath, discusses the origin of the heath on naked dune sand. He gives an important place to algæ and moss protonema, since they precede other vegetation, forming the first humus and causing the sand grains to cohere. It is doubtful if these lower plants are so important as sand-binders along Lake Michigan. Rothert and Klinge have studied the coast vegetation of Russia.

The French dunes have been very carefully studied by Flahault alone and also in association with Combres. Some work has also been done in France by Constantin and Masclef. Willkomm's work in Spain and Portugal, covering a period of nearly fifty years, is very complete and satisfactory. Daveau has worked out the conditions along the coast of Portugal. On these more southern dunes, the plant species resemble those along Lake Michigan less than do those in northern Europe, but the life habits are the same.

The dune flora of South Africa has been touched upon by Drude, that of Chile by Kurtz and Reiche, that of northern Siberia by Kjellman, that of New Zealand by Diels. The tropical dunes of Indo-Malaysia have been studied in detail by Schimper, and are fully discussed in his work on the Indo-Malay strand flora and also in his recent Plant Geography. In the latter work there are several excellent discussions of sand dune vegetation, accompanied by photographs from a number of regions. The tropical dunes have totally different species, but even there the dominant dune-formers are grasses with the same life habits as Ammophila.

Dunes may be formed in deserts and inland regions apart from large bodies of water. Those in the Sahara and in the deserts to the northeastward have been more or less studied. Brackebusch has described dunes in Argentina.

In the United States dunes are common along the Atlantic coast, especially in Massachusetts, New Jersey, North Carolina, and Florida. On the Pacific coast they also occur extensively. None of these marine dunes have been exhaustively studied from the ecological standpoint. One of the best works that has ever appeared on strand floras is that by MacMillan on the shores at the Lake of the Woods. The dune formation is not extensive there, but is most admirably treated. As would be expected, there are many species common to Lake Michigan and the Lake of the Woods. The sand hills in the interior have been studied by Rydberg, Hitchcock, and Pound and Clements. Hill has studied the dune floras about Lake Michigan for many years, and although he has not written a great deal along ecological lines, he has had the ecological standpoint thoroughly in mind and the author has received from him a number of valuable suggestions.

THE UNIVERSITY OF CHICAGO.

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BRIEFER ARTICLES.

ORIGIN OF TIMBER BELTS.

In the north central part of Kansas along the Republican river in Clay and Cloud counties, the streams are bordered by narrow interrupted belts of timber. These belts are from a few rods to half a mile in width. The region is near the border line of the great plains, east of the Rocky mountains, where trees are almost entirely absent. Until recently the country was swept annually by devastating prairie fires, and it was only on the sandbars, on the inner side of the river bends where the sedimentary deposits were comparatively free from herbage, that young trees had any chance of surviving. In the region studied, the Republican river passes through the Dakota sandstone, and its bed is very sandy. During overflows the lower portions of the bends are covered by a layer of sand and rich organic detritus, affording an immediate substratum for the vigorous development of young trees, while at the same time the growth of grass and weeds is almost entirely checked because they are partly or completely covered up by the deposits.

The succession of woody plants is as follows: Along the water's edge or at the outer margin of the sandbars, there first grows up a zone of the common long-leaved willow, *Salix longifolia* Muhl. As this advances with the growth of the bar, it is replaced by the black willow, *Salix nigra* Marsh. The black willow finally gives way to a thick growth of cottonwood, *Populus monilifera* Ait. All young timber belts are therefore made up of three zones:

1. A zone of *Salix longifolia* Muhl., generally several rods in width.
2. A strip of *Salix nigra* Marsh, usually a narrower zone than the first.
3. A wide zone of *Populus monilifera* Ait., which makes up the timber belt proper.

I have had some of these young timber belts under observation for nearly twenty years, some from their very beginning, and I find that it is only after the cottonwood has formed a rather thick forest of good-sized trees that other trees common to the region begin to take posseson of the soil. In the limestone region in the southeastern part of Clay county, there are several species of trees which do not pass over into the sandstone district. The trees which finally crowd out the cottonwood are few in number and are of the following species: *Negundo aceroides* Moench, *Gymnocladus Canadensis* Lam., *Gleditschia triacanthos* L., *Cercis Canadensis* L., *Fraxinus viridis* Mx., *Ulmus fulva* Mx., *Ulmus Americana* L., *Celtis occidentalis* L., *Morus rubra* L., and *Juglans nigra* L. Thus, in the older forests, the cottonwood trees stand here and there as solitary giants, crowded on all sides by the newer occupants.

There seems to be good evidence that these timber belts never advanced outward from the river, but rather that fire and prairie grass were continually encroaching upon the forest areas, restricting them to narrow belts along the river, although the river bottoms in some places are several miles in width.—JOHN H. SCHAFFNER, *Columbus, O.*

THE SPREADING OF BUFFALO GRASS.

I HAVE several times read the statement that the buffalo grass, *Buchloe dactyloides* Engelm., is being crowded out and exterminated in regions which have been settled for some time. This does not agree with my own observations, which extend through a period of over twenty years in Clay county, Kansas, a region where this grass is quite common, although it occurs only in small patches here and there in the prairie. Of course, the sum total in a given region would be less at the present time than formerly on account of the great areas now under cultivation. But in the pastures the grass has spread considerably. I know of patches which are at present from six to ten times their original area twenty five years ago when the country was first settled. There are also many places, formerly destitute of buffalo grass, which are now practically covered with it, other species being crowded out.

This increase of the buffalo grass in the pastures is without doubt due to the continual tramping of cattle, which destroys the other common prairie-grasses but does not seem to be injurious—rather beneficial— to the buffalo grass.

I also know of a patch in a yard which has remained a thick sod for twenty five years, while all the other grasses have long since been destroyed and their place taken by weeds and introduced grasses.

In the region under consideration, the buffalo grass usually grows along the banks of ravines and at the base of hilly slopes where conditions are rather unfavorable. There are a number of characteristic grasses, which go to make up the great bulk of the prairie. The little blue stem or bunch grass, *Andropogon scoparius* Michx., grows mostly on the hills and ridges, while the big blue stem, *Andropogon furcatus* Muhl., occupies the more level and richer areas. Along with the big blue stem the Indian grass, *Chrysopogon nutans* (L.) Benth., and the switch grass, *Panicum virgatum* L., occur in considerable abundance, while in very wet ravines it is largely displaced by the slough grass *Spartina cynosuroides* Willd.—JOHN H. SCHAFFNER, *Columbus, O.*

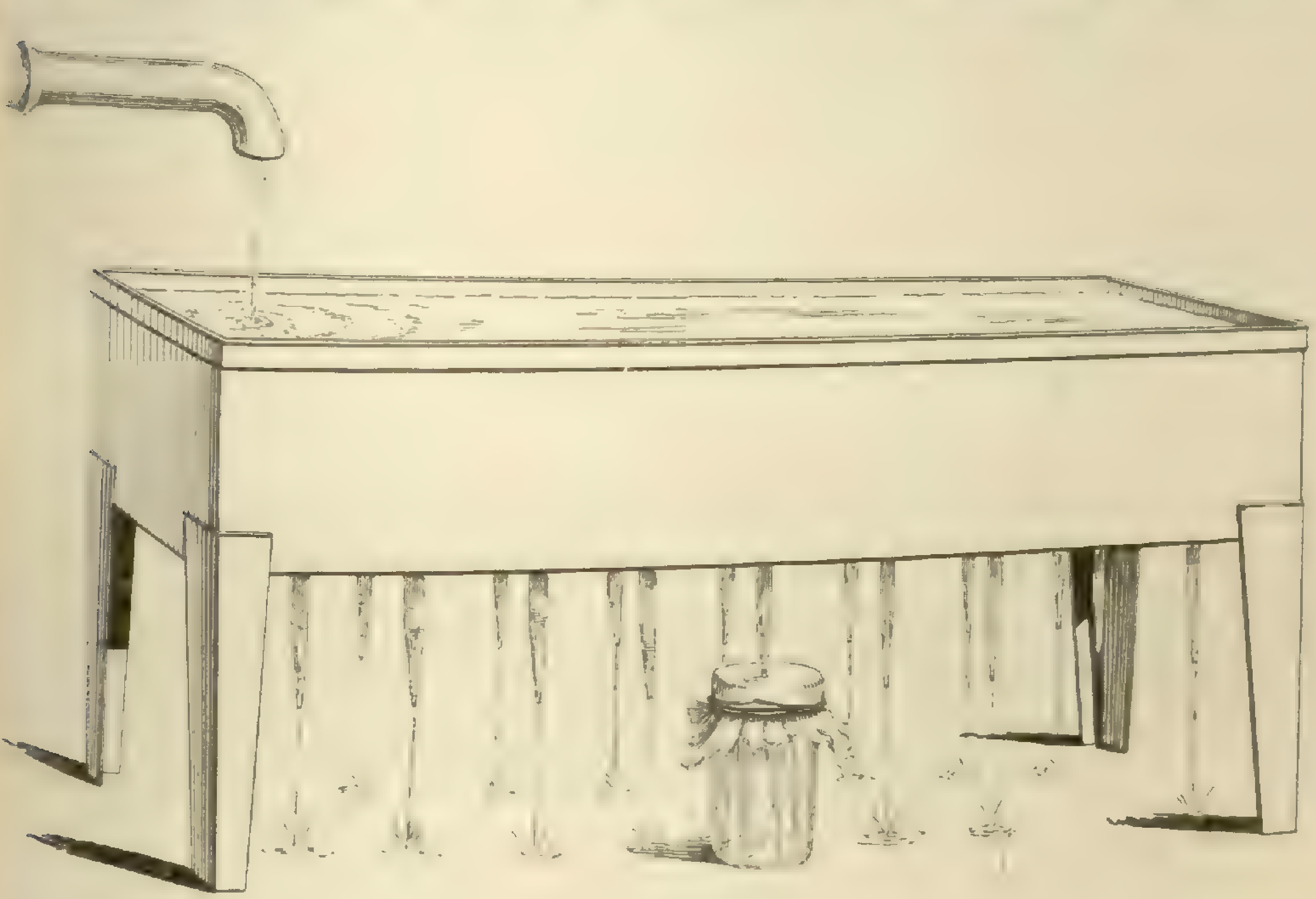
A WASHING APPARATUS.

(WITH FIGURE.)

FOR some time we have felt the need in our laboratory of an apparatus adapted to washing material fixed in certain solutions, such as chromic acid and Flemming's chromo-aceto-osmic mixture. Such a device should be at once simple in structure, capable of accommodating several bottles of material at once, and should provide a current of water strong enough to insure a constant and gentle agitation of the material, and at the same time one not so violent as to injure the most delicate tissues.

Such an apparatus has been made for our own laboratory, and after a year of use it fills all the requirements so perfectly that it has been thought desirable to publish a description of it in the hope that others might profit by our experience. It consists, essentially, of a trough supported on legs, and provided with a cork bottom, through holes in which are passed glass tubes drawn out to a point at the lower end. When the material is ready for washing, a fine meshed cloth is stretched over the mouth of the bottle, and held in place by a rubber band. The bottle is then placed beneath the trough, and one of the tubes is lowered until the pointed end projects through the cloth into the bottle. If water be then allowed to run into the trough until it is nearly full, the head of water will be sufficient to cause it to flow through the glass tube into the bottle with just enough force to produce a gentle agitation or circulation of the material. The water passes off through the meshes of the cloth.

The trough may, of course, be made of any material, of any size, nd high enough to accommodate any bottle. The one here described of tin, 6.25^{cm} deep, and of a size to fit the ordinary sheet of insect rk, $8.75^{cm} \times 29.5^{cm}$. The space beneath the trough is 7.5^{cm} high. The cork bottom should be at least 1^{cm} thick to be sufficiently stiff. The holes are 1.8^{cm} from the edge, and are 3.75^{cm} apart. This gives oom for eighteen 25^{mm} bottles of material to be washed at one time



A WASHING APPARATUS.

thout crowding. The cork is supported by having the sides and ends the trough turned in 5^{mm} at the bottom. In addition to this, the ottom should be held by at least four narrow metal cross pieces, both ove and below, to prevent the cork from warping when wet. The ass tubes are 6.75^{cm} long, with an inside diameter of 3^{mm}. They uld fit just tightly enough in the holes to allow of being slipped up nd down. The trough is kept in a sink under one faucet, and only a all stream is needed to keep it running. One needs only to see the paratus at work to be convinced of its completeness.—**ELIAS J. RAND**, *Botanical Laboratory, Cornell University.*

PHACELIA COVILLEI AT MT. CARMEL, ILL.

ON May 5, 1889, Mr. F. V. Coville found a Phacelia on Larkspur land, on the Potomac, about five miles above Washington, D. C.[1]

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[1] BOT. GAZ. **21**: 233. 1896.

This was sent to Dr. Sereno Watson, who regarded it as a new species, and published it under the name of *Phacelia Covillei* in the sixth edition of Gray's manual. It was not found again on the Potomac until April 1895, when it was taken at several points on the Potomac river opposite its original station.

On May 8, 1888, in company with Dr. W. Trelease, I found this plant growing in low, rich, bottom lands along the border of a cypress swamp, in Knox county, Ind., two miles east of Mt. Carmel, Ill. I had found it before, in several localities, near Mt. Carmel, and always in low lands that are subject to overflow during times of high water, but had regarded it as *Macrocalyx Nyctelea* (L.) Kuntze (*Ellisia Nyctelea* L.), until I finally found the real Macrocalyx. I was then unable to locate the first plant until after I had received the sixth edition of Gray's Manual, by means of which I found it to be *Phacelia Covillei* Watson. This diagnosis has been confirmed by Dr. N. L. Britton and others. Its general appearance is much like that of *Macrocalyx Nyctelea*, while the large globose, one-celled capsule places it with the Phacelias. These peculiarities have led some of the botanists at Washington to suspect it as being a hybrid between *Phacelia dubia* and *Macrocalyx Nyctelea*; but as the former species is not found in the vicinity of Mt. Carmel this can hardly be true.

Mt. Carmel, Ill., and Washington, D. C., are nearly in the same latitude, and a comparison of the published local floras[2] of these two localities shows that they have many species in common. The flora at Washington receives intrusions from the maritime and Alleghanian regions, while the flora at Mt. Carmel has been modified by many additions of southern and western immigrants, so that it is not surprising to find this riparian plant growing on the banks of the Wabash as well as on those of the Potomac. It is reasonable to suppose that it occurs at intermediate stations, and perhaps to the westward, but that it has been considered to be the Macrocalyx and has been so labeled when collected.—J. SCHNECK, *Mt. Carmel, Ill.*

[2] WARD, Bull. U. S. Nat. Mus. **22** : 104. 1881; Schneck, Geolog. Surv. Ind. 1875 : 504.

EDITORIAL.

Science, falsely so called

THE leading article in the *Popular Science Monthly* for February bears the sonorous title, "Vegetation a remedy for the summer heat of cities. A plea for the cultivation of trees, shrubs, plants, vines, and grasses in the streets of New York, for the improvement of the public health, for the comfort of summer residents, and for ornamentation." With tree planting in cities the BOTANICAL GAZETTE is in warmest sympathy, but the arguments advanced by Stephen Smith, M.D., LL.D., "to revive the project of giving the Department of Parks jurisdiction over the trees in the streets, and require it to plant and cultivate additional . . . . vegetation" are calculated to astonish the botanist, and make him grieve over the popular inculcation of such ridiculous physiology. "The real problem to be solved may be thus stated. How can the temperature of the city of New York be modified during the summer months?" According to the writer trees can do this, because "forests and even single trees . . . . tend to equalize temperature, preventing extremes both in summer and winter." This they do "through their own inherent warmth, which always remains at a fixed standard both in summer and winter." Then, since "the vaporization of liquids is a frigorific process," and plants "emit into the atmosphere considerable quantities of water vapor," it is evident that "vegetation tends powerfully to cool the atmosphere during a summer day." Since "man may live in close proximity to marshes from which arises the most dangerous malaria with the utmost impunity [hold, bad malaria!], provided a grove intervene between his home and the marsh," it is fortunate that "at the period of the day when malaria and mephitic gases are emitted in the greatest quantity and activity, this function of vegetation is most active and powerful."

It is greatly to be regretted that such utterly erroneous conceptions of the work of plants, of which the above are only samples, should find publication at all, and much more that they should appear in a journal which speaks in the name of science, as the *Popular Science Monthly* claims to do. Or must "popular science" be considered merely a pseudonym for grotesque or sentimental fol-de-rol?

OPEN LETTERS.

A READY SUPPLY OF VAUCHERIA.

TEACHERS of botany are often put to much trouble in securing good fruiting material of the stock algæ at times of the year when material cannot be obtained out of doors. A good supply of Vaucheria can be obtained at any time with very little trouble. Five or six weeks before the material is needed some Vaucheria should be obtained in any greenhouse from the surface of the soil of potted plants, and brought to the laboratory without disturbing the mats. After removing as much of the soil as possible the mats should be thrown into a jar half full of water and put where the sun may shine upon them. In the experiments made it was found that after a week considerable change in the color of the filaments had occurred, and after five or six weeks the material was found in excellent condition, showing both methods of reproduction, zoospores in all stages of germination, and the vegetative body also thriving better than if grown on soil. In this way a supply free from other algæ and from sand, and in amounts sufficient to supply classes of over two hundred students, was obtained at short notice. The species experimented with was *Vaucheria sessilis*.— **BRUNO A. GOLDBERGER**, *Chicago.*

STAINING TECHNIQUE.

BASIC fuchsin (1 per cent. aqueous solution) can be very satisfactorily substituted for safranin in the Flemming triple stain, and at least in many cases gives a more brilliant red. The same elements seem to take the fuchsin as take the safranin. The stain goes through the same manipulations, clearing, etc., as are used with the Flemming combination, without visible alteration. Slides are best left in the fuchsin over night and excess extracted with 35 per cent. alcohol. This extraction is slow enough to be easily controlled. —**H. F. ROBERTS**, *The University of Chicago.*

CURRENT LITERATURE.

BOOK REVIEWS.

The nutrition of plants.

THIS central subject of plant physiology, as to which there is so great an amount of popular misapprehension, is the one most directly important to all growers of plants. The Germans are fortunate in having had for some years a clear and interesting little book on this subject, of which the second edition has recently been issued.[1] Dr. Adolph Hansen, the author, prepared the original book more for his own satisfaction, he says, than with any ulterior purpose; but it found so wide a circle of readers that both author and publisher seem under necessity to provide a new edition.

The book treats of the source of carbon, the organs by which CO_2 is absorbed and elaborated, the significance of light for photosynthesis (this term is used throughout), and the product. The author then considers the nitrogen supply, the mineral constituents, the organs (roots) by which they are chiefly obtained, and the movements of water, including its loss and the regulation thereof. As "nutrition" is used in its widest sense, he further discusses the production of proteid, the translocation of plastic substances, and respiration. The non-green plants, both spermatophytes and fungi, receive scant treatment in a concluding chapter.

The book is admirably written in clear and simple language, and the facts are handled in an attractive way. Theoretical considerations are not excluded, and even these are lucidly presented. There is little to criticise unfavorably. Only one fundamental definition we must dissent from — a definition which the author should reconsider—"Foods of the plant are those substances without which the plant could not exist."

We should be glad to see such a book in English. It would be immensely useful to plant growers and for popular reading.—C. R. B.

The completed host index.

THE thirteenth volume of Saccardo's *Sylloge fungorum*, a notice of the first half of which was given in a previous issue of this journal,[2] is now complete, having been issued in parts. It has been prepared by Dr. P.

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[1] HANSEN, ADOLPH: Die Ernährung der Pflanzen. 12mo. pp. iv + 299. figs. 79. Wien: F. Tempsky; Leipzig: G. Freytag. 1898. *M* 5.

[2] BOT. GAZ. 25:287.

Sydow,[3] with some assistance from P. A. Saccardo, G. Lindau, and P. Hennings, to whom acknowledgment is made in the preface. The work is brought down to the end of the year 1897.

The type is good, and the spacing ample, so that the volume can be consulted with readiness and comfort. The host species are arranged in a single alphabet, following the authority of the *Index Kewensis*, with the fungi associated with each species named immediately beneath.

The attempt has been made to use but one name for each species of host and of fungus, thus omitting synonyms. The imperfections in the literature of the fungi have made it especially difficult to follow out the plan with the desired success. It is easy to point out names that should have been omitted, as they are clearly synonyms, and to mention others that should have been included. But such shortcomings are incident to the subject, and only emphasize the necessity for early monographic work.

To anyone determining parasitic fungi the volume will prove of the greatest service, and, in connection with the descriptive part of the great *Sylloge*, will be especially welcome.—J. C. A.

What is "vital energy?"

THE PROBLEM before the physiologist is the nature of living matter. Anything that contributes to a solution of this problem is welcome. Dr. Oscar Loew has already done much to make possible a better understanding of the chemistry of protoplasm and its products. In a work published in London in 1896 entitled *The energy of living protoplasm*, he set forth in English the views which now find a more complete exposition in German under the title, *The chemical energy of living cells*.[4] As the former work was not received by the GAZETTE for review, a somewhat extended résumé of his views may now be useful.

After giving a historical summary of previous views as to the causes of vital activity, he avers that the *primum movens* of the living cell is to be sought neither in heat nor electricity, but in a specific chemical activity, viz., the assumption of oxygen by the living substance. The main question, then is, "What conditions lead to the activity of cell respiration and to the transformation of the heat thereby produced into the chemical energy of the living cells?"

The living protoplasm, "at once artificer, work-shop, and plastic material."

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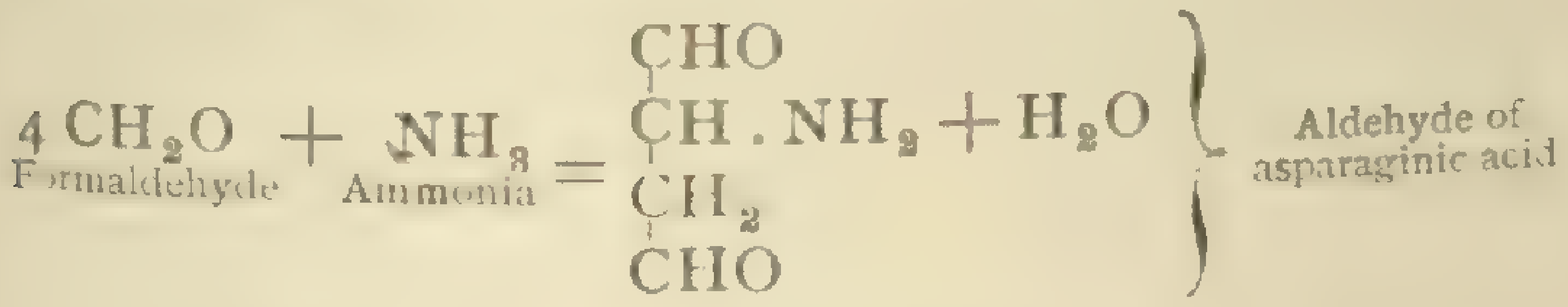
[3] SYDOW, P.—Sylloge fungorum omnium hucusque cognitorum digessit P. A. Saccardo, Vol. XIII; Index universalis et locupletissimus nominum plantarum hospitum specierumque omnium fungorum has incolentium quæ usque ad finem anni 1897 innotuerunt. Roy. 8vo, pp. vi + 1340. Berolini: Fratres Borntraeger, 1898.

[4] LOEW, OSCAR: Die chemische Energie der lebenden Zellen. 8vo. pp. xii + 175. München: Dr. E. Wolff. 1899. *M* 5; geb. *M* 6.

s Hanstein well says, is declared by Loew to be no variable mixture of pro-eids (as Reinke, Verworn, Pfeffer, and others hold), but organized proteid, hose vital energy depends on its chemical character, as its vital functions epend on its organization. Dead protoplasm and living protoplasm are hemically different; the former is chemically stable while the latter is emically active or labile, *i. e.*, possessing much kinetic chemical energy, it ters into reaction very readily. Death is the transformation from the labile the stable form of proteid, by the displacement of certain atoms in e molecule. A labile proteid sometimes occurs as a reserve substance in ants. This is the material whose reaction with silver salts in weak mmoniacal solution was discovered by Loew and Bokorny and was thought to be the reaction of living protoplasm.

With the proteid are combined certain salts of sodium, calcium, mag-esium, and iron oxid, and phosphoric acid. The rôle of these materials is scussed, and their importance in the chemical processes pointed out.

After enumerating the biochemical work, and discussing the nature of atalytic processes at some length, two chapters are devoted to the formation proteids in fungi and in green plants. In another are explained clearly e author's well-known views that labile proteids arise in the higher plants om formaldehyde and ammonia, by way of the aldehyde of asparaginic d. Thus:



$$\underset{\text{Formaldehyde}}{4\,CH_2O} + \underset{\text{Ammonia}}{NH_3} = \left.\begin{array}{l} CHO \\ CH\,.\,NH_2 + H_2O \\ CH_2 \\ CHO \end{array}\right\} \text{Aldehyde of asparaginic acid}$$

$$\underset{\text{Aldehyde of asparaginic acid}}{3\,C_4H_7NO_2} = \underset{\text{An intermediate product}}{C_{12}H_{17}N_3O_4} + 2\,H_2O$$

$$\underset{\text{Intermediate product}}{6\,C_{12}H_{17}N_3O_4} + 12H + H_2S = \underset{\text{Lieberkühn's proteid formula}}{C_{72}H_{112}N_{18}SO_2} + 2H_2O$$

Of course, in the absence of any definite knowledge of the molecular weight of proteid or its exact composition, it is evident that these details can y be theoretical; nevertheless the theory may prove highly useful.

The ninth and tenth chapters (written in collaboration with Th. Borkorny) scuss the labile proteid which they found as a reserve material, its chemical aracteristics, and its relation to living proteid.

In the eleventh chapter the author seeks to show upon what the lability nd consequent activity) of the protoplasm depends. It is probably due, he s, to the simultaneous presence in the molecule of aldehyde (CHO) and do (NH_2) groups; that is, the proteids of living protoplasm are amido-ehydes, which at death lose their aldehyde groups wholly and the amido ps in large part. Recalling the dictum of Sachs, "The dead organism ead simply because it has lost its irritability," one may well couple with it e dictum of Loew, "No irritability without lability."

The concluding chapters are devoted to the presentation of a theory of respiration which may be called the catalytic theory. Loew holds that contact with the living proteid, whose intense kinetic energy is predicated, so increases the lability of the CHOH groups in sugars and of the CH_2 groups in the fatty and amido acids that combination with free oxygen follows, to such an extent that these substances are totally oxidized. In the course of this oxidation, the O_2 is split up into its atoms, but not before. By the energy thus set free as heat, appropriate substances may be raised to the labile condition, and other work done. The protoplasm, in rendering the foods labile, suffers a loss of energy, but this loss is again covered by the energy set free in the oxidation. If free O is wanting, the sugar breaks up into other products (fats, lactic acid, etc.), constituting intramolecular respiration. Loew combats vigorously the accepted idea of a continuous dissociation and regeneration of living substance, holding that the impairment involved would be more likely to result in death than in life. For, if the amount of thermogenous foods in a cell becomes considerably diminished, the lability of the plasma proteid leads to its own direct assumption of oxygen; and when only a small part of the proteid has been altered by oxidation, disorganization follows; that is, death by hunger.

The theory of vital energy thus set forth is a consistent one, and is supported by many strong arguments from the chemical side. It is, of course, diametrically opposed to the view which Pflüger and many other physiologists hold, that lability of protoplasm is due to the presence of cyanogen groups (CN), and that respiration is the oxidation of protoplasm itself, at which climax of chemical power it decomposes continuously, to be as continuously rebuilt out of available foods.

There are difficulties in both theories, and physiologists will do well to read and ponder this clear and interesting book by Dr. Loew.—C. R. B.

NOTES FOR STUDENTS.

M. Edmond Gain has endeavored to determine whether the material known as *alinite*, which is recommended for increasing the fertility of the soil through the activity of bacteria, was efficient for this purpose. The active microbe of this product is *Bacillus Ellenbachensis* α (*B. Megatherium* DeBary). His experiments, though not numerous enough to determine the question satisfactorily, indicate that "the addition of alinite produces a beneficial effect, which manifests itself in greater vegetative development of the plants [buckwheat and flax], and in a larger crop of seeds."[5]—C. R. B.

Puriewitsch has determined that the splitting of most glucosides by fungi is accomplished extracellularly, through the splitting action of emulsin, into glucose and benzene derivatives.[6] This action is carried on both by germinating spores and by developed mycelium. The glucose produced is first completely used by the plant; the benzene derivatives are then used very much more slowly, if at all. Amygdalin, as attacked by most fungi, forms an exception to the foregoing statement. Though it may be split by emulsin into glucose, benzaldehyde, and hydrocyanic acid, it is usually broken up by invertin into glucose and amygdalic acid, the latter being further decomposed into glucose and mandelic acid.—C. R. B.

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[5] Revue gén. de Botanique **11**: 18–28. 1899.

Berichte der deutsch. bot Gesells. **16**: 368. 1898.

SINCE Strasburger's thorough work on *Polygonum divaricatum* (1879) little or nothing has been done with the embryology of any nearly related plant. A recent article on Rumex[7] shows that in this genus the origin and development of the megaspore is the same as in Polygonum, viz: an archesporial cell divides into a primary tapetal cell and a sporogenous cell, the latter giving rise to four megaspores, one of which germinates. The small size of the nuclei makes this rather unfavorable for cytological study, but, judging from the plates, the very clearly defined sequence preceding the formation of the endosperm nucleus (secondary nucleus) indicates that Nawaschin's recent theory could be shown to be inapplicable in this case.—C. J. CHAMBERLAIN.

DR. HANS MOLISCH presented to the Imperial Academy of Sciences in Vienna at the meeting on December 1, 1898, a paper upon "The Secretion of Palm Wine and its Causes." Heretofore the bleeding of the palm when the inflorescence was amputated has been ascribed to root pressure. Three circumstances awaken doubt of this: (1) Were root pressure the cause, it should be observable at the base of the stem; (2) bleeding occurs in the very tall palms, at heights (19–28^{m}) which it is doubtful if root pressure could reach; and (3) bleeding takes place during full leafage.

Researches showed that in Cocos and Arenga root pressure was scarcely to be detected at the base of the stem, and from borings at this point no sap escaped, though it poured out abundantly above. Moreover, a spadix, completely severed, continued to bleed for one or two days and developed a not insignificant bleeding pressure. The osmotic pressure, therefore, according to Molisch, has its origin not in the root but in the axis of inflorescence of Cocos and in the adjacent upper part of the stem in Arenga.[8]—C. R. B.

HERR LIND introduces an article on the penetration of fungi into limestone and bones[9] with a twelve-page summary of the previous work on the subject, from which it is evident that the greatest knowledge has come through dental studies. It has long been known that fungi, algæ, and lichens can corrode or bore into rock, bone, or shell, and it has been assumed that they did this by excreting at the growing tip an acid which dissolved the calcareous material that it touched. Miyoshi in 1895 proved that chemotactic irritation induced the penetration of a cellulose membrane by fungi. Experimental proof of the cause and manner of penetration of calcareous objects seems to appear first in Lind's work. By adopting careful antiseptic precautions, he proves that a fungus may penetrate marble, chalk, eggshell, or bone plates, 0.07 to 0.2^{mm} in thickness, in eight or ten days. To do this there must be a chemotactic stimulus, usually furnished by some organic or inorganic food material that is needed by the plant. The stimulus seems useful to cause the acid-forming surface to be pressed close to the rock in order to secure a sharply localized action. Microscopic examination shows that the fungus may pass directly through crystals. From a study of the action of oxalic and carbonic acids, the author concludes that the latter is primarily responsible for the etching, though oxalic acid may be accessory, especially in the presence of sodium chlorid which may afford hydrochloric acid by combination. The greater prevalence of such perforations in marine than in fresh water shells is thereby explained.— F. L. STEVENS.

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[7] FINK BRUCE: Contribution to the life history of Rumex. Minnesota Bot. Studies. **2**: 137–153. *pl. 9–12*. 1899.

[8] Cf. Œsterr. bot. Zeits. **49**: 74. 1899.

[9] LIND, K.: Ueber das eindringen von Pilzen in Kalkstein und Knochen. Jahrb. f. wiss. Bot. **32**: 603–634. 1898.

ITEMS OF TAXONOMIC INTEREST are as follows: In *Bulletin of the Torrey Botanical Club* **26**: 63–71. 1899) CHARLES H. PECK has described twenty new species of fleshy fungi.— ELIZABETH G. BRITTON (*ibid.* 79–81) has described a new Tertiary moss (Rhynchostegium) which is probably the oldest species yet found in this country.— ANNA MURRAY VAIL (*ibid.* 106–107) continues her studies of the Leguminosæ, presenting the genus Dolicholus (Rhynchosia), with sixteen species.— CHARLES MOHR (*ibid.* 118–121) has described new species of Prunus, Physalis, and Solidago from Alabama.— AVEN NELSON (*ibid.* 122–134) continues his description of new species from Wyoming, the present fascicle containing seventeen species in widely scattered genera. — K. M. WIEGAND (*ibid.* 135–137) has described some new species from Washington, and also (157–171) has published a revision of Listera, including twelve species, seven of them North American, two of which are new.— In *Pittonia* (4: 25–52. 1899) E. L. GREENE publishes twenty seven new species in miscellaneous genera, the largest number being added to Sisyrinchium (5) and Silphium (4); discusses chronologically early specific types in Chamæcrista as distinct from Cassia, discovers some twenty-three, and transfers them from Cassia to Chamæcrista; brings up certain neglected generic types, recognizes *Phyla* Loureiro for *Lippia* Mx., separates *Sieversia* Willd. from *Geum*, and establishes *Vanclevea* Greene upon *Grindelia stylosa* Eastwood.— Circulars 9 and 10 of the Division of Agrostology contain contributions by LAMSON-SCRIBNER and WILLIAMS, thirteen new species and several new varieties of Poa being described, as well as species in Eragrostis and Elymus.—A continuation of Schinz's (Zürich) work on the African flora appears in *Bull. Herb. Boiss.* (7: 24–65. 1899), the separate being published as *Contrib. Bot. Mus. Univ. Zürich.* The most important papers are as follows: Gramineæ (7 n. spp.), by E. HACKEL; Leguminosæ (12 n. spp. and a new genus *Neorautanenia*), by HANS SCHINZ; and the fourth installment of Convolvulaceæ, by H. HALLIER.—J. M. C.

THE QUESTION of the sexuality of Collema is discussed by Baur[1] who adds some interesting observations to our imperfect knowledge of the peculiar conditions preceding the ascocarp in this form. He confirms Stahl's original observation and gives us a more detailed account of the cytology of the archicarp and trichogyne than has yet been presented. It seems that the cells of the spirally twisted archicarp and the trichogyne which rises from it are in communication with one another by delicate strands of protoplasm that run through a pore in the center of each cross-wall. The entire structure consists of 25–40 cells, 15–20 constituting the archicarp and the remainder making up the multicellular trichogyne. Each cell contains a single nucleus, that in the terminal cell of the trichogyne being slightly larger than the others. Spermatia were observed fused with the projecting tips of the trichogyne.

A medium sized thallus of Collema will produce every season, spring and autumn, many hundreds of archicarps with their trichogynes, but of these less than one per cent mature fruit. The others gradually wither from above downwards, and the basal portions become a part of the vegetative mycelium of the lichen. No spermatia were ever observed attached to withering trichogynes. Sometimes lichen thalli will bear thousands of archicarps, and yet produce no apothecia. Baur believes he has found the explanation in the absence of spermogonia on such specimens. An apothecium lives for several years and the first asci are formed from six to twelve months after fertilization.

Baur's conclusions on the mechanism of fertilization are not final, his paper being in the nature of a preliminary contribution. From observations on several specimens he believes that, as the result of fertilization, the nuclei of the trichogyne gradually become disorganized, beginning from above, until only the cells of the archicarp remain unchanged. Finally all the cells above the archicarp break down. Baur points out two ways in which fertilization might be accomplished. Perhaps the sperm nucleus passes down through the disorganized cells of the trichogyne and fertilizes one or more cells of the archicarp; or it is possible that the sexual act may take place in the terminal cell of the trichogyne, and that a fusion nucleus makes its way into the archicarp, giving rise by its activity to the system of hyphæ that constitutes the ascocarp. The last explanation is apparently suggested by Oltmanns' recent work on the Rhodophyceæ.—B. M. DAVIS.

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[1] BAUR: Zur Frage nach der Sexualität der Collemaceen. Ber. d. deut. bot. Gesells. **16**: 363. 1898.

BULLETINS of the experiment stations not heretofore mentioned relating to plant diseases are as follows: "Diseases of plants," by A. P. Anderson (S. C., no. 36, pp. 1–17, illust.), gives a brief popular account of the rôle of fungi and bacteria as disease agents. The same author writes upon "The asparagus rust in South Carolina" (S. C., no. 38, pp. 1–10, illust.), while Byron D. Halsted gives more extended observations upon "The asparagus rust, its treatment and natural enemies" (N. J., no. 129, pp. 1–20, illust.). In a "Preliminary report upon diseases of the peach; experiments in spraying peach trees," Aug. D. Selby (Ohio, no. 92, pp. 179–268, illust.) gives a large amount of information with much original observation, to which a serviceable index is added. The same investigator also writes upon "Some diseases of wheat and oats" (Ohio, no. 97, pp. 31–61, illust.) especially of smuts, rust, scab and glume spot. The Fusarium causing scab of wheat is said to be *F. roseum* Lk. The ascigerous stage was found and almost certainly identified as *Gibberella Saubinetii* (Mont.) Sacc. Cultures were made, but attempted infection of living plants was not successful. In an account of "Pea canning in Delaware" by G. Harold Powell (Del., no. 41, pp. 1–16, illust.) is a description (pp. 8–11) of sun scald of peas caused by *Ascochyta Pisi*. A comprehensive treatment of the "Diseases of the tomato" by P. H. Rolfs (Fla., no. 47, pp. 117–153, illust.) recounts practical observations upon the cause and prevention of eleven diseases. Black rot (Macrosporium) is the most prevalent, and can be prevented by spraying with Bordeaux mixture; a bacterial disease is common and less easily controlled; and what is locally known as "white mold," although due not to a fungus but to *Phytoptus Calcladophora* Nal., is not yet reported from any other state. The bulletin is well written and printed, and is a model for a practical treatise. Observations on "Cotton rust" are given by F. S. Earle (Ala., no. 99, pp. 281–309) in addition to previous accounts by Dr. Atkinson. B. M. Duggar (Cornell, no. 163, pp. 339–363, illust.) has studied "Three important fungous diseases of the sugar beet," which are root rot (*Rhizoctonia Betæ* Kühn), leaf spot (*Cercospora beticola* Sacc.) and scab (*Oospora scabies* Thax.). Much original information is given regarding the fungi, the diseases they cause, and remedies, followed by a bibliography. The same author presents important notes on "Peach leaf curl and notes on the shot-hole effect of peaches and plums" (Cornell, no. 164, pp. 371–388, illust.), emphasizing the value of early spraying with Bordeaux mixture for the former, and showing that the latter is often produced by spraying and other non-fungous causes. A concise account, with observations within the state of Vermont, is given by L. R. Jones (Vt., no. 66, pp. 1–16, illust.) of "Club root and black rot.

two diseases of the cabbage and turnip," the former mycetozoan and the latter bacterial, both widely distributed and common. "Suggestions as to spraying" by J. A. Tillinghast and G. E. Adams (R. I., no. 52, pp. 1–48, illust.) is a convenient and well prepared handbook of plant diseases amenable to spraying, with directions for the work. It is a more valuable bulletin than the title indicates. An extended report on "Spraying cucumbers in the season of 1898," by F. A. Sirrine and F. C. Stewart (N. Y., no. 156, pp. 375–396, illust.) shows the value of frequent use of Bordeaux mixture during the latter part of the season against *Plasmopara Cubensis*. The advantages and methods in the use of "Formalin for grain and potatoes," especially for smut of oats and wheat and scab of potatoes, are presented by J. C. Arthur (Ind., no. 77, pp. 38–44). The chemical composition of "Some spraying mixtures" has been determined by George W. Cavanaugh (Cornell, no. 149, pp. 719–721). Spraying calendars are issued by the Michigan (Special no. 12) and Ohio (no. 102) stations, the latter being especially complete and convenient.

Copies of the above bulletins may usually be obtained without expense by sending a request to the *Director of the Station*, addressed respectively in the order given above: Clemson College, S. C.; New Brunswick, N. J.; Wooster, Ohio; Newark, Del.; Lake City, Fla.; Auburn, Ala.; Cornell Univ., Ithaca, N. Y.; Burlington, Vt.; Kingston, R. I.; Geneva, N. Y.; Lafayette, Ind.; and Agricultural College, Mich.—J. C. A.

A RECENT paper by Nordhausen on parasitic fungi[11] is of great value. It starts with the scientific conclusions of Miyoshi regarding the penetration of membranes by fungi and extends the work, laying an accurate foundation for the knowledge of the conditions of natural infection of plants by invading fungi. The paper deals with such questions as the method of infection; the influence of the condition of the host upon resistance to infection; the cause of epidemics, etc. Nordhausen experiments with hemisaprophytes, and proves that sporelings, growing in a drop of pure water on the epidermis cannot gain entrance to the plant without nourishment additional to that contained in the spores. However, when injected hypodermically in vessels or pith cavities, they grow and cause death throughout the structure. So it seems that a spore can infect living cells without the intervention of a period of saprophytic existence if unprotected or poorly protected cells are available. It is the epidermis that protects the tissue from invasion. Flower leaves do not have a resistant epidermis, and some most valuable observations were made regarding the effects of spores germinating on petals. A yellow spot marked the position of the spore, and the protoplasm of the adjoining cells was brown even eight hours after the spore had arrived and *before its germ*

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[11] NORDHAUSEN, M.: Beiträge zur Biologie parasitärer Pilze. Jahrb. f. wiss. Bot. 33: 1–46. 1899.

tube had entered. This must have been due to a toxin freed during the germination. The author investigated this further and proved that it was a very vigorous substance. The browning of the cell walls precedes death of the protoplasm. The author concludes, from what seems to be ample evidence, that there are two substances produced, an enzyme that browns the wall and digests it, thus producing a soluble substance which attracts the germ tube chemotropically. Later there is a toxin which kills the cell and this affords the fungus a base of supplies for a saprophytic existence. Thereafter it may easily invade surrounding tissues to any extent. Slight humidity favors germination of the spore, but great dampness dilutes the toxin and enzyme; therefore the optimum destruction is at a moderate humidity. The author holds that, even in the case of subepidermal wounds or the hypodermic injection of sugar (Miyoshi), the fungus does not attack live cells, but its saprophytic existence is thus assured while it liberates its toxin; it is also possibly aided by weakening of the resistance of the cell through the unnatural conditions. Many suggestions are made regarding the influence of the condition of the host upon resistance; among them, that normal structure counts for much (*e. g.*, thick epidermis); growing portions are susceptible because thin walled; similarly, great dryness weakens the resistance of the ectoplasm, and lack of light results in a thin wall, etc. The author attributes epidemics largely to climatic conditions, or to a breeding place for the fungus where it may obtain food for its existence as a saprophyte. He explains that in such times any particular host species succumbs probably because it furnishes a foothold in some way for a temporary saprophytic existence of the parasite. Or, a given plant may through its own specific heat cause an exactly favorable amount of dew to be condensed on its surface.

Two more questions are investigated, viz.: Can a representative pure saprophyte (*e. g.*, Penicillium, Mucor) under certain conditions become a parasite? Why are they so seldom parasitic? The first is answered abundantly in the affirmative (*e. g.*, fruit decay). Why they are not often parasites is shown by the fact that they cannot penetrate a live cell, even of the mesophyll, although they can penetrate cell walls and may live among them. Host cells may even live for sometime in contact with the mycelium. It seems, therefore, that these fungi make no toxin, as do the parasites or hemisaprophytes. In the case of wounds the reaction of the plant is important. The host may set to forming parenchyma; then the advance of the fungus will depend upon how much it can hinder this recuperative process. It is fight to the death between the host and the fungus. Botrytis is usually victorious, but not always, as victory is to a certain extent dependent upon the amount of resistance of the host. In the case of saprophytes the host's resistance is more important, as the fight is waged in every cell anew, but to even such fungi, fruits are so slightly resistant as to be an easy prey. It is to be hoped that the author will extend his work to the consideration of the behavior of parasitic fungi.— F. L. STEVENS.

THE ELABORATE MONOGRAPH on starch published a few years ago by Meyer is now followed by a comprehensive account of the state of knowledge regarding inulin and carbohydrates of somewhat similar nature which occur in many plants.[12] Dr. Hugo Fischer gives in the first half of this paper an account of the chemical nature of inulin. Like most of the polysaccharides the composition of its molecule is not known. It is built up of fructose units, but the number of molecules of fructose in each molecule of inulin is not known, and the suggestions vary within wide limits. The low osmotic pressure of solutions of inulin indicate that the molecule is very large. Several modifications of inulin have been described, but the independent existence of these as chemical individuals is not demonstrated. It is possible that some of them (perhaps all) are decomposition products of inulin.

Fischer describes the formation of the spheroidal masses of inulin in plant tissues and compares with these the other spheritic structures occurring in plants, particularly hesperidin (a glucoside occurring in Citrus rind) and calcium phosphate or malophosphate. The latter includes a nucleus of non-crystalline material (perhaps containing proteid). In its spheritic form inulin resembles starch grains in many ways, particularly in swelling upon the imbibition of water at ordinary temperatures and in double refraction. Inulin, however, does not swell like starch, on the application of hot water, alkalies, etc., but dissolves like soluble crystals or breaks up into granules which dissolve.

In the last part of his paper Fischer describes the occurrence of inulin, gives a list of the plants in which it has been found (about 140 species, including 95 Compositæ, about 25 species of allied families, a half dozen Violaceæ, two monocotyledons, and a few algæ), and discusses the methods and places of manufacture, transportation, and storage.

The most important theoretical part of this monograph is the discussion of the structure of inulin masses and starch grains, particularly in view of the trichite theory of the structure of starch grains proposed by Meyer. Meyer held that the swelling of starch was *due* to the spheritic structure, ignoring the facts that many spherites do not swell and that many bodies which do swell are non-spheritic. Fischer shows that when starch grains are air dry (still, however, containing 20 per cent. of water), this water is not free, since it does not indicate its presence by a test with cobalt chloride. Both inulin and starch absorb certain solutions of coloring matters. Did these solutions enter into the spaces between the crystals, as Meyer holds, all should be alike absorbed. But some coloring substances do not penetrate. To explain this it would be necessary to assume that their molecules were large enough to approach the limit of visibility, since the trichites are, according to Meyer, so slender as to approach this limit. This is, of course, an absurd assumption. Fischer shows also that the storing of colors is difficult or impossible to explain on the crystal-trichite theory. It is well known, however, that colloids and even liquids (*e. g.*, clove oil) are able to store up coloring matter, but no crystals are known which do this. Moreover, starch and inulin which have been stained while wet and then air-dried cannot be decolorized by alcohol or clove oil. It is impossible to understand why alcohol cannot penetrate between the trichites and withdraw the coloring matter, since, even, in the air-dry condition, there is still 20 per cent. of water around the trichites. The relations of starch to iodine, also, are difficult to explain on Meyer's theory. Only when wet does starch give the well-known blue reaction with iodine; dry grains react brown. When blue grains are air-dried they become brown. To explain this upon the crystal theory would require us to assume that when the trichites are surrounded by a little water the iodine solution is brown, but when the crystals are surrounded by a larger quantity of water it is blue; again, an impossible assumption.

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[12] COHN's Beiträge zur Biologie der Pflanzen 8: 53–10. 1899.

Fischer also criticises Bütschli's theory of "foam" structure for bodies capable of swelling, in which an attempt is made to explain the force developed by imbibition by osmotic action of the substance occupying the "bubble" spaces. His own view, stated very briefly, is that both in starch and inulin a true chemical relation exists between water and the molecules of amylose and inulin, in consequence of which the molecular structure is different according as greater or less quantities of water are present, after the analogy of some crystals. Watery amylose and inulin have different physical properties from those they possess when air-dry. Only in the watery condition can they dissolve in their own substance and store certain coloring matters; others are insoluble. Iodine, whose tints differ according to the solvent, is dissolved in watery amylose with a blue tint. When air-dry the iodine is not in solution, but is distributed through the amylose in fine solid particles.

Swelling, Fischer holds, is thus a purely molecular process — a loose combination of molecules with water after the fashion of water of crystallization in some salts. Upon an increase of water this condition passes without break into the state known as solution, that is, a still looser relation of the molecules to water. The fact that imbibition occurs for inulin, starch, cellulose, gums, gelatin, etc. only with water, supports this view. The radial structure of both starch and inulin spherites is explicable as due to radial cracking. These cracks are exceedingly minute in starch and into them the air does not enter. They are larger in inulin spherites and are penetrated by air. The double refraction of both bodies is due to the strains under which the masses exist; strains which are not completely relieved in starch until the expansion due to true imbibition has passed over into the semi-solution of the gelatinous state. Both inulin and starch grains are thus considered to be masses of colloid, homogeneous, except for the radial cracks. The material is arranged in layers or zones arising from internal differentiation.—C. R. B.

AMONG ANNUAL REPORTS from experiment stations, not heretofore noticed in these pages, are three from the New York station. Those for 1895 and and 1896, much delayed in appearing, have about one third the space devoted to the reports of the horticulturist, S. A. Beach, and mycologist, F. C. Stewart, and their assistants. The more strictly bota nical portion in the 1895 report covers about 70 pages, dealing with fungous diseases and their remedies, with nine excellent plates, and in the 1896 report there are 100 pages and ten fine plates. A part of this matter had been published elswhere. In the 1897 report no botanical matter appears that had not already been issued in bulletin form.

The report of the Rhode Island station for 1897 contains an article on use of sulfur and sulfate of Ammonia for prevention of potato scab (pp. 254–255) by H. J. Wheeler and G. E. Adams, showing that both substances have some value; and also an article on the asparagus rust (pp. 317–321) by L. F. Kinney, giving an account of a serious outbreak at Concord, Mass., the spread of the disease in Rhode Island, and attempts to control it.

The report of the Maine station for 1897 contains a valuable résumé of important writings on the acquisition of atmospheric nitrogen (pp. 114–140) by W. M. Munson, in which he cites both foreign and American literature, and appends a bibliography of 120 numbers. F. L. Harvey writes upon plants of the season (pp. 179–191), especially the weeds about which inquiries have been made, the king-devil (*Hieracium prœaltum* Vill.) receiving most attention, including its history, distribution in America, habits and methods of prevention. The blighting effect of wind on maple leaves in spring is described, and some diseases are mentioned. Three species of stinkhorn fungi have been found in the state, *Phallus dœmonum* Rumple, *P. impudicus* L. and *Mutinus brevis* B. & C., which are described with the aid of a half-tone plate from a photograph of the first two.

In the report of the Delaware station for 1896–7 F. D. Chester gives an account of experiments for prevention of peach rot and apple scab by spraying, and of potato scab by use of sulfur (pp. 20–38), and also proposes a systematic arrangement of the species of the genus Bacterium (pp. 53–145), giving diagnostic characters and providing a bibliographic index.

The Hatch station of Massachusetts for 1897 devotes 24 pages (pp. 47–70) and two good plates to the report of the botanists, G. E. Stone and R. E. Smith. The subjects covered are the value of spraying, potato maladies of the year, "drop" of lettuce (*Botrytis*), asparagus rust (*Puccinia Asparagi*), the blight of pears, quince rust (*Gymnosporangium clavipes*), brown rot of stone fruits (*Monilia fructigena*), chrysanthemum rust (*Puccinia Tanaceti*), a bacterical disease of the geranium, and four leaf blights of native trees.

The last report issued by the California station, being for 1895–1897, includes an account of the natural vegetation of alkali lands (pp. 63–75) by J. Burtt Davy, illustrated with eight fine plates from photographs. The plates show *Frankenia grandifolia campestris* Gr., *Distichlis spicata* (L.) Greene, *Atriplex polycarpa* (Torr.) Wats., *Bigelovia veneta* (H. B. K.) Gr., *Suæda* Torreyana Wats., *Sporobolus airoides* Torr., *Allenrolfea occidentalis* (Wats.) Kuntze, and *Modiola decumbens* Don.

The report of the Connecticut station for 1897 is issued in parts, and part three (pp. 159–222) is entirely devoted to botany. The articles are by W. C. Sturgis, and present, with much fullness, a study of the mildew of lima beans (*Phytophthora Phaseoli* Thax.), stem rot of carnations, which was found to be due to a Fusarium, prevention of fungous diseases of celery and apple, and an extended classified index to the literature of fungous diseases, found chiefly in the publications of the U. S. Department of Agriculture and the state experiment stations.

The Arizona report for 1897–8 is very brief, containing only 40 pages. The botany (pp. 160–169) by J. W. Toumey treats especially of root-rot of Alfalfa, and sunburn of fruit trees, the latter being due to the action of a hot sun while the plants are in a wilting condition.

In the Wisconsin report for 1897–8 there are two important botanical studies by E. S. Goff. The first is an investigation of the resumption of root growth in spring (pp. 220–228), showing that the rootlets of trees and shrubs do not die away during winter, as usually taught, but that growth is resumed in spring where it ceased in the previous autumn. The second is a study of the morphology and habits of the strawberry plant (pp. 229–238). Both are well illustrated by cuts.

In the Vermont report for 1897–8 both the botanist and horticulturist write upon subjects that are largely botanical. The botanists, L. R. Jones and W. A. Orton, present a variety of topics (pp. 189–236). Valuable results are recorded in spraying potatoes and apples for fungous diseases, and in treating potatoes, especially with formalin, for scab. In 1897 the asparagus rust and club-root of cabbage were first reported in the state. A list of the parasitic fungi of the state with their hosts includes 17 species of Phycomycetes, 27 of Erysipheæ, 15 of Ustilagineæ, and 80 of Uredineæ. There are interesting observations on weeds, and on impurities in clover seed. A study of the flow of maple sap shows close correspondence between changes of temperature and rates of flow, and by use of lithium it was found that the sap flowed equally well up or down the trunk, but very slowly in a radial direction. F. A. Waugh, the horticulturist, reports (pp. 237–306) with great fullness upon the study of plums, their pollination, self-sterility, hardiness, and blossoming seasons, to which is added a monograph of the Wayland group of plums, all amply illustrated. There are also notes on lilies, on physiological constants, on use of enzyms in germination, and on winter-killing of buds, all treated with originality, and full of valuble facts.—J. C. A.

In *Journal de Botanique* 13: 127, M. Ph. Van Tieghem proposes to discriminate the non-sexual reproductive bodies now called spores into three categories. (1) The term *spores* he retains for those bodies which are formed by an adult plant and develop into a new "adult" individual. All the fungi and most of the algæ form spores; the gemmæ or brood-buds of bryophytes are spores; but no vascular plants produce spores. (2) The term *diodes* (from δίοδος, passage = transition) is suggested for reproductive bodies, arising on the adult, which develop into a "rudimentary" body, the prothallium, thus establishing a transition between the "adult" and "rudimentary" stages. Thallophytes and bryophytes have no diodes; they are peculiar to vascular plants. The diodes may be all alike (isodiody), or differentiated into microdiodes and macrodiodes (heterodiody). (3) All the bryophytes, the Rhodophyceæ and Mucoraceæ produce and set free viable cells which are not spores, because they do not arise from the adult stage, and not diodes, because they produce directly an adult individual. To them is given the name *tomies*, from τομή, to cut, because by them the total development from the egg is "cut" into two unequal parts, the smaller preceding the tomies, the larger following their growth. The rudimentary structure in which they are formed is the tomiogone.

The application of these new terms is obvious enough, but to the writer they seem worse than useless because they obscure homologies—which is also obvious enough.—C. R. B.

NEWS.

Professor Dr. W. Zopf has been called from Halle to Münster as successor to Dr. O. Brefeld.

Dr. Otto Stapf has been promoted to chief assistant in the Kew herbarium, succeeding Mr. W. B. Hemsley.

A committee has been formed to collect funds for a marble bust of the late Dr. Guiseppe Gibelli, professor of botany in the University of Turin.

Professor Dr. G. Karsten, of Kiel, has been called to the assistant professorship of botany at Bonn, as successor to Professor Dr. A. F. W. Schimper.

The botanical institute of Rome, under the direction of Professor R. Pirotta, held during March and April a series of public conferences on the nutrition of plants.

Dr. J. M. Janse has been appointed to the directorship of the botanical garden at Leyden, a post held by the late Professor W. F. R. Suringar for more than thirty-five years.

Associate Professor W. C. Stevens, of the University of Kansas, has recently been promoted to the professorship of botany, and Assistant Professor M. A. Barber to associate professor of bacteriology and cryptogamic botany.

Dr. A. P. Anderson has been appointed assistant professor of botany, in charge of plant physiology, in the University of Minnesota, *vice* Dr. D. T. MacDougal, who recently resigned to accept the directorship of the laboratories of the New York Botanical Garden.

Dr. L. Buscalioni, assistant in the botanical institute at Rome, left on March 15 for a long expedition in Brazil. There, accompanied by a collector for the botanical museum, he intends to explore the little known regions of the upper affluents of the Amazon, and to cross the Andes.

Mr. Chas. A. Keffer, for the past five years assistant chief of Division of Forestry, U. S. Department of Agriculture, has resigned to accept a position as head of the department of horticulture and agriculture in the New Mexico Agricultural College at Mesilla Park, New Mexico.—*The Forester*, March.

A BUST of Dr. Increase A. Lapham, a pioneer naturalist of Wisconsin (1875), was recently unveiled in the magnificent new public library and museum of Milwaukee. Lapham made extensive collections of plants in Wisconsin and northern Michigan, which are to be found in the great herbaria. His own herbarium is at the University of Wisconsin.

L'ABBÉ Count Francesco Castracane degli Antelminelli, the venerable student of diatoms, died at Rome on the 27th of March. He was born at Fano, July 19, 1817, and was therefore, in his eighty-second year. At the time of his death he was president of the Academie Pontifice des Nuovi Lincei.— DE TONI.

DR. A. W. CHAPMAN died suddenly at his home in Apalachicola, Florida, April 6, in his ninetieth year. This venerable American botanist, so long identified with the flora of the southern states, continued his botanical work until the last. A biographical sketch, prepared by Dr. Charles Mohr, will be published in the next number of the BOTANICAL GAZETTE.

THE SOCIÉTÉ de physique et d'histoire naturelle, of Geneva, announces a competition for the prize of 500 francs, founded by A. P. DeCandolle, for the best unpublished monograph of a genus or family of plants. The manuscripts, to be written in Latin, French, German, Italian, or English, must be sent to the president of the society before January 15, 1900. If agreeable to the author of the work receiving the award, the society will publish it in its quarto *Mémoires*.

MR. J. DÖRFLER, the compiler of the best and most complete *Botanists' Directory*, expects to issue a new edition about the beginning of 1900. Address slips will soon be distributed. It is to be hoped that all botanists will furnish the information desired. The great value of a complete directory is patent, but its accuracy and completeness depend largely on the cooperation of all to whom address blanks come. Mr. Dörfler's address is Barichgasse 36, Wien, III, Austria.

THE GROUNDS of the new Cruickshank botanical garden, in connection with the University of Aberdeen, are shortly to be laid out. The total area is between five and six acres, of which about half an acre is placed at the disposal of the agricultural department of the University. Provision is to be made at present only for a museum, and for the study of systematic botany; later the trustees contemplate erecting suitable quarters for physiological work. Dr. J. W. H. Traill is the director.

THE TWELFTH annual session of the Marine Biological Laboratory opens at Woods Hole, Mass., on June 1, and closes October 1. Two courses of instruction in botany are offered, one in cryptogamic botany and one in cytology, to begin July 5 and close August 16. The botanical staff consists of Dr. Bradley Moore Davis, instructor in botany, The University of Chicago, and George T. Moore, Jr., assistant in botany, Harvard University. Fourteen botanists are also announced for lectures on special subjects. Further information may be obtained from Dr. Davis.

FROM THE annual announcement of the Woods Hole Marine Biological Laboratory we clip the following:

"After the close of the current volume in April, the *Zoological Bulletin* will be continued under the title, the *Biological Bulletin*, and be published under the auspices of the Marine Biological Laboratory. The scope of the *Bulletin* will be enlarged so as to include general biology, physiology, and botany. It will further include occasional reviews and reports of work and lectures at the Laboratory. The *Bulletin* will be open, as heretofore, to scientific contributions from any source."

THE DEATH of Charles Naudin occurred suddenly on March 19th. Naudin was director of the experimental garden at the Villa Thuret, Antibes, an adjunct of the Jardin des Plantes, Paris. He was born at Autun in 1815, and was therefore in his eighty-fourth year. His experimental researches on Cucurbitaceæ, enabling him to untangle and classify the confusing varieties of gourds, cucumbers, and melons; his *Traité général d' horticulture*, one of the most useful of horticultural works; and his numerous experiments and writings on acclimatization and hybridization make secure his fame as one of the greatest garden botanists of the century.

DR. GUSTAV RADDE, director of the museum in Tiflis, has recently published the third memoir in the Engler and Drude series *Die Vegetation der Erde*, entitled *Grundzüge der Pflanzenverbreitung in den Kaukasusländern*, which will be shortly reviewed in our pages. In recognition of Radde's services as founder and director of the Tiflis museum, his long and active scientific career of forty-five years, and especially his investigations on the fauna and flora of eastern Siberia and principally in the Caucasus, which culminate in the recently published memoir, the Imperial Geographical Society of St. Petersburg has conferred upon him its highest honor, the Nicolajewicz gold medal.

MISS CLARA E. CUMMINGS has just issued another fascicle of *Lichenes Boreali-Americani*. This fascicle contains numbers 221–250, and is the most valuable yet issued. Of the thirty species, twenty-three are mountain forms, from the Franconia mountains in New Hampshire, mountains of Colorado, and one from the Sierra Nevada. Other specimens are from Montana, Nebraska, Pennsylvania, Louisiana, and the District of Columbia. Twelve of the thirty specimens are rock forms, mostly of the genera Lecanora and

Lecidea. These have all been compared with the Tuckerman herbarium, and as the rock lichens are peculiarly difficult to determine, they are the most valuable forms to be included in an authentic set. The author still needs the assistance of collectors, and the sets will be issued as fast as material can be obtained.

Dr. A. F. Woods, of the United States Department of Agriculture, has an account in *Science* of April 7, of some interesting results he has recently obtained relative to a so-called disease of the vine. It appears that some years ago two French investigators, Viola and Sauvageau, discovered what they supposed to be a new parasitic organism causing much damage to the vine. Dr. Woods has conducted a similar investigation, and reaches the conclusion that their results are due entirely to the reagents employed in the study. That is, by using certain staining fluids, the contents of vegetable cells may be made to assume at will the form described by the French authors as their new organism. Dr. Woods was able to produce precisely similar results in lily, tobacco, tomato, rose, hyacinth, and even in spirogyra cells. The complete report will soon be published by the Department of Agriculture.—*Plant World*, May.

At the meeting of the Academy of Science of St. Louis, on April 3, Mr. Trelease exhibited a plaster cast of a gigantic monstrosity of *Cereus marginatus*, known as the Rosa de Organo, presented to the Missouri Botanical Garden by Professor Frederick Starr, and reported that this formation was locally abundant at points south from Aguas Calientes. The speaker exhibited a large number of comparable cactus monstrosities from the planthouses of the Missouri Botanical Garden and the collection of the president of the Cactus Association of St. Louis, and a similar deformity of one of the cactus-like Euphorbias of the African region, commenting on this teratological type. It was shown that for the purpose of gardeners, for whom these unusual forms appear to possess a considerable interest, they are commonly divided into two types, in one of which, commonly designated by the varietal name *cristata* or *cristatus*, the monstrosity takes the form of a fan or a contorted ridge, while in the other, commonly designated by the varietal name *monstrosa* or *monstrosus*, it consists of irregular bunching of the branches, and an interruption of the customary longitudinal ridges of such a genus as Cereus.—W. T.

From *Nature* for March 16, 1899, we take the following announcements of forthcoming botanical books:

Mr. Edward Arnold announces "A manual of botany," by David Houston; and "Wood: its natural history and industrial applications," by Professor G. S. Boulger.—The list of Messrs. C. J. Clay & Sons (Cambridge University Press) includes "Fossil plants," a manual for students of botany and geology, by A. C. Seward, F. R. S., Vol. II; and "The soluble ferments and fermentation," by Professor J. Reynolds Green, F. R. S. — Messrs. Duckworth & Co. give notice of "A glossary of botanic terms," by B. Daydon Jackson; "A text-book of agricultural botany, theoretical and practical," by Professor John Percival; and "A text-book of plant diseases caused by cryptogamic parasites," by George Massee. — Mr. W. Engelmann (Leipzig) announces "Grundzüge der Pflanzenverbreitung in den Kaukasuslanden," by Dr. Gustav Radde. — Mr. Henry Frowde announces Goebel's "Organographie der Pflanzen," translated by Professor I. Bayley Balfour, F. R. S.; and Pfeffer's "Pflanzenphysiologie," translated by Dr. A. G. Ewart. — Messrs. Longmans & Co. promise "The flora of Cheshire," by the late Lord de Tabley.—The list of Messrs. Swan Sonnenschein & Co., Ltd., contains a new edition of "Handbook of practical botany," by Professor E. Strasburger, translated and edited by Professor W. Hillhouse.

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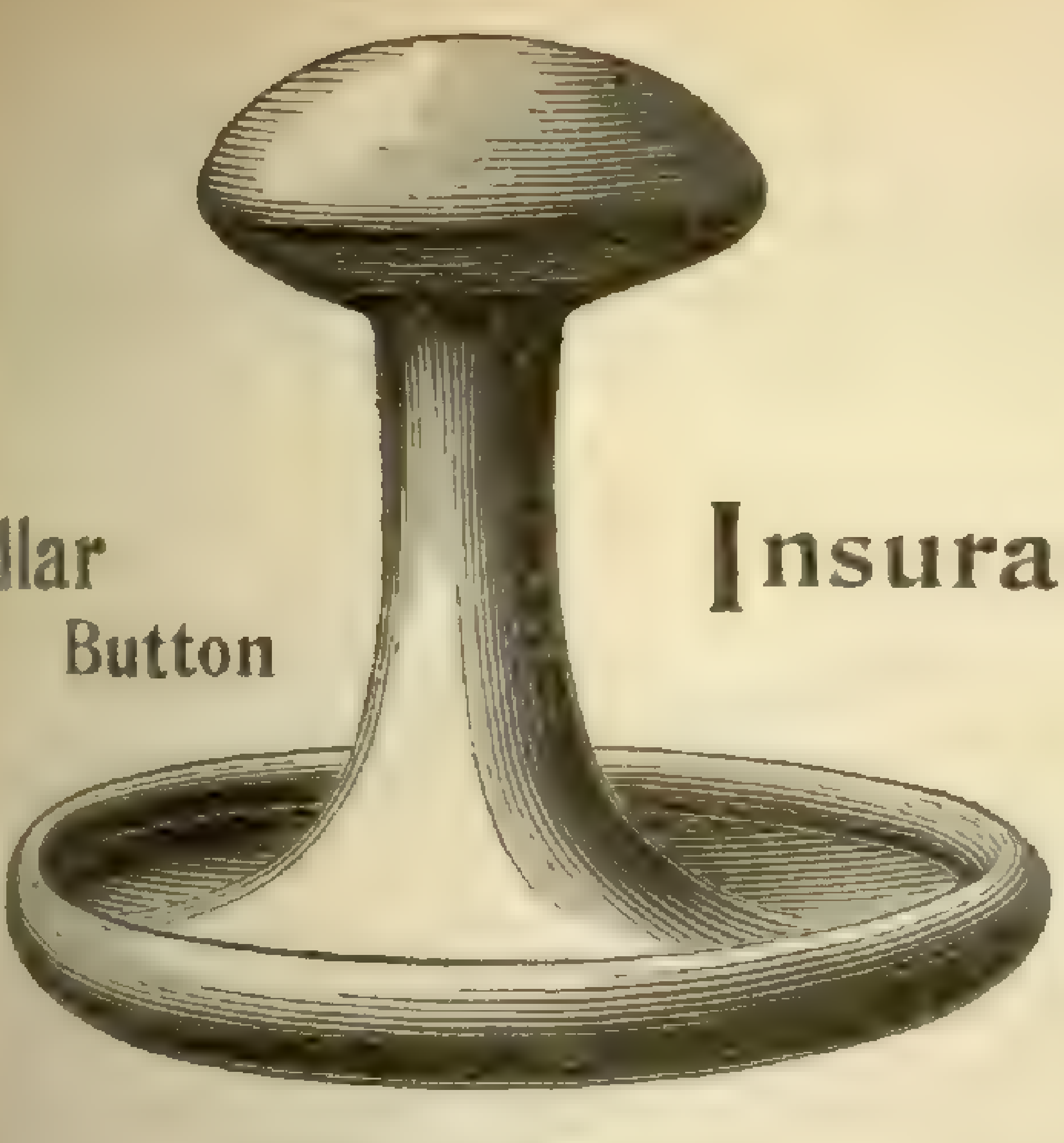

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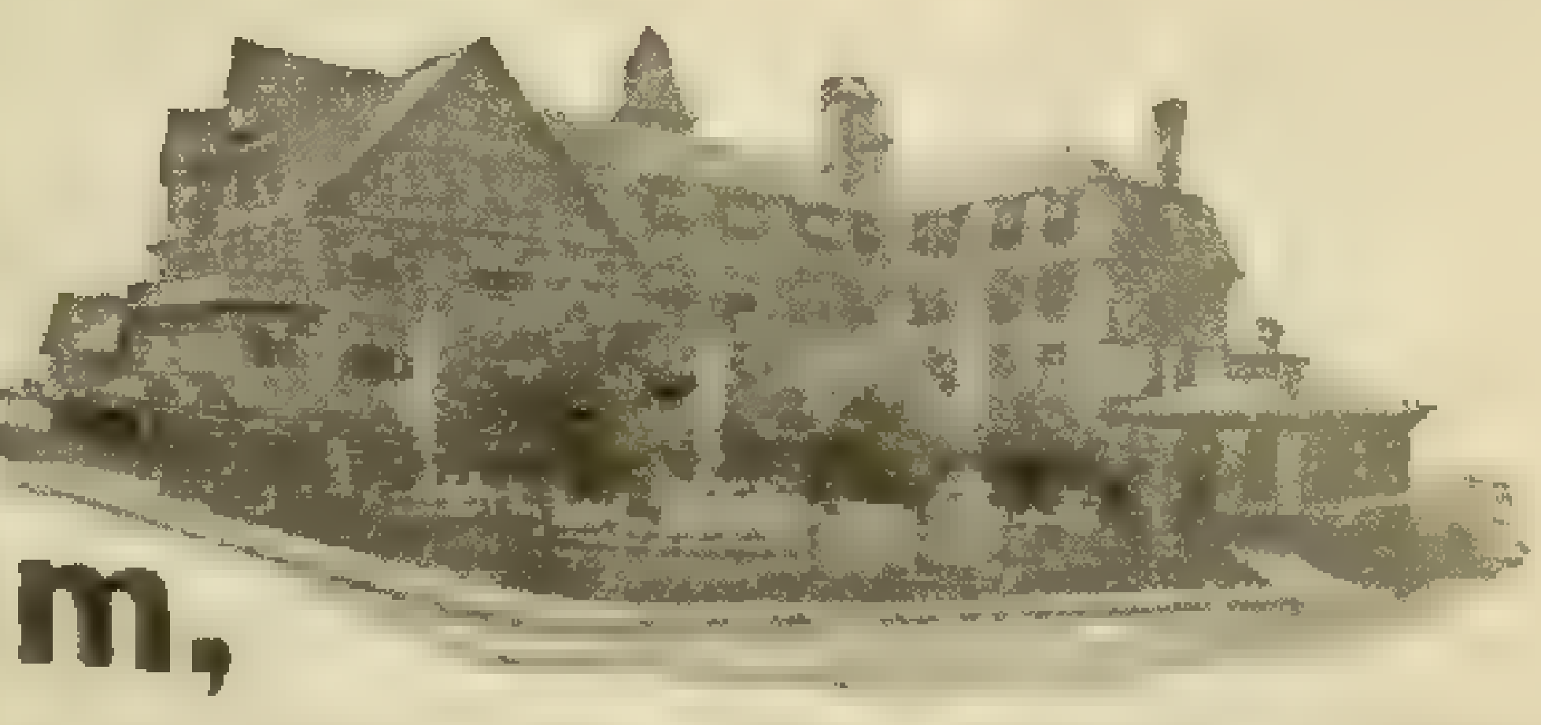

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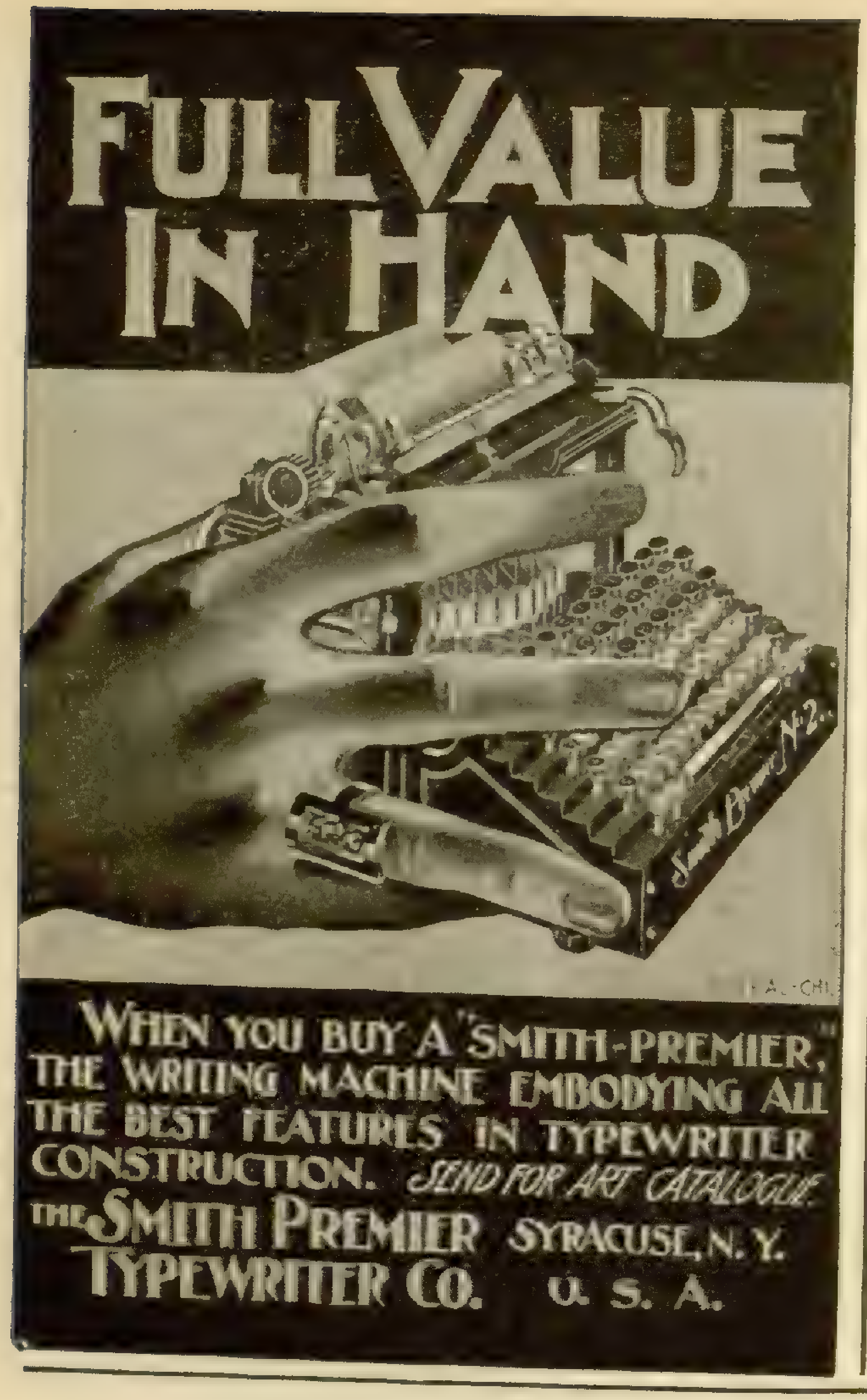
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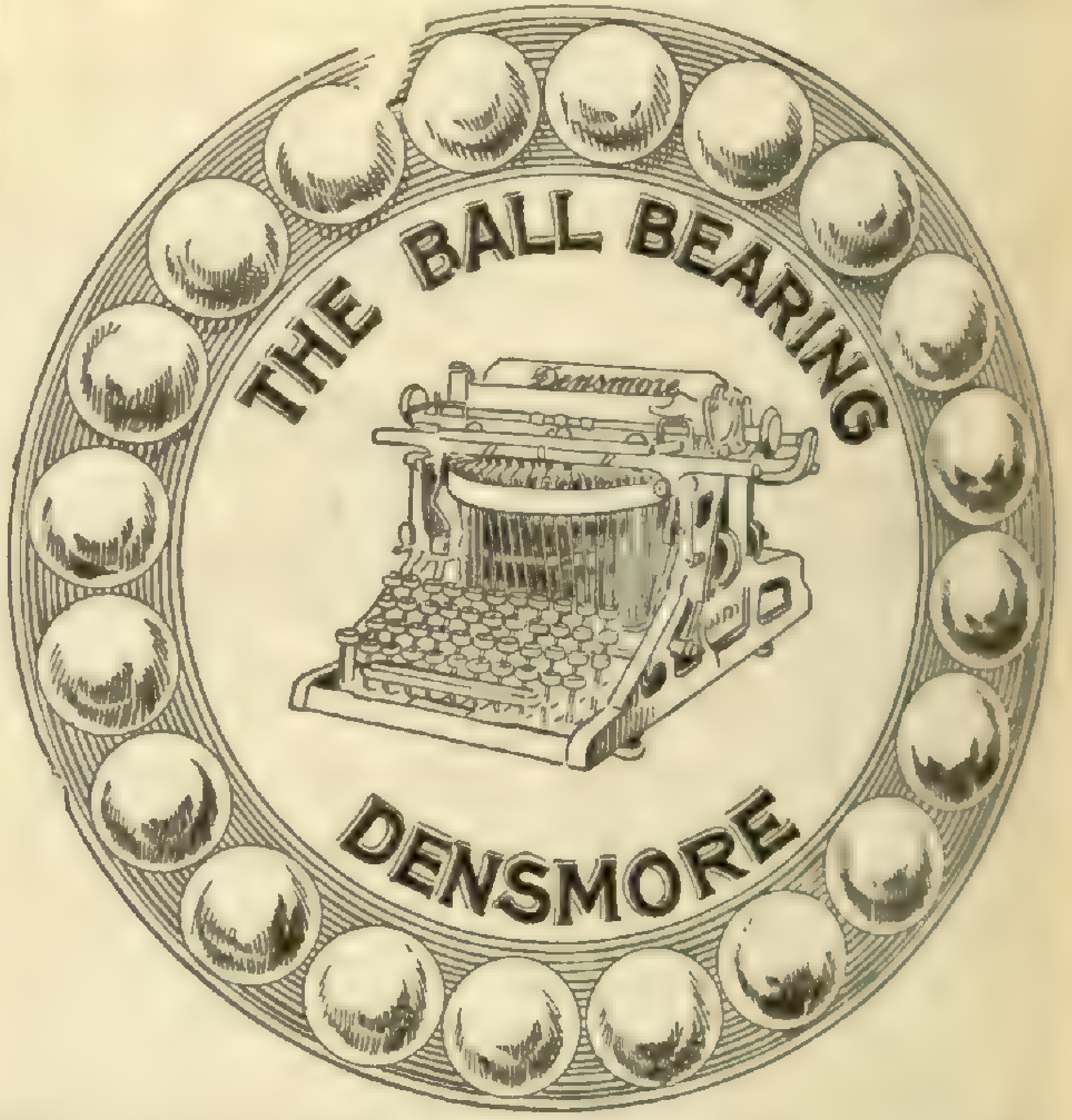

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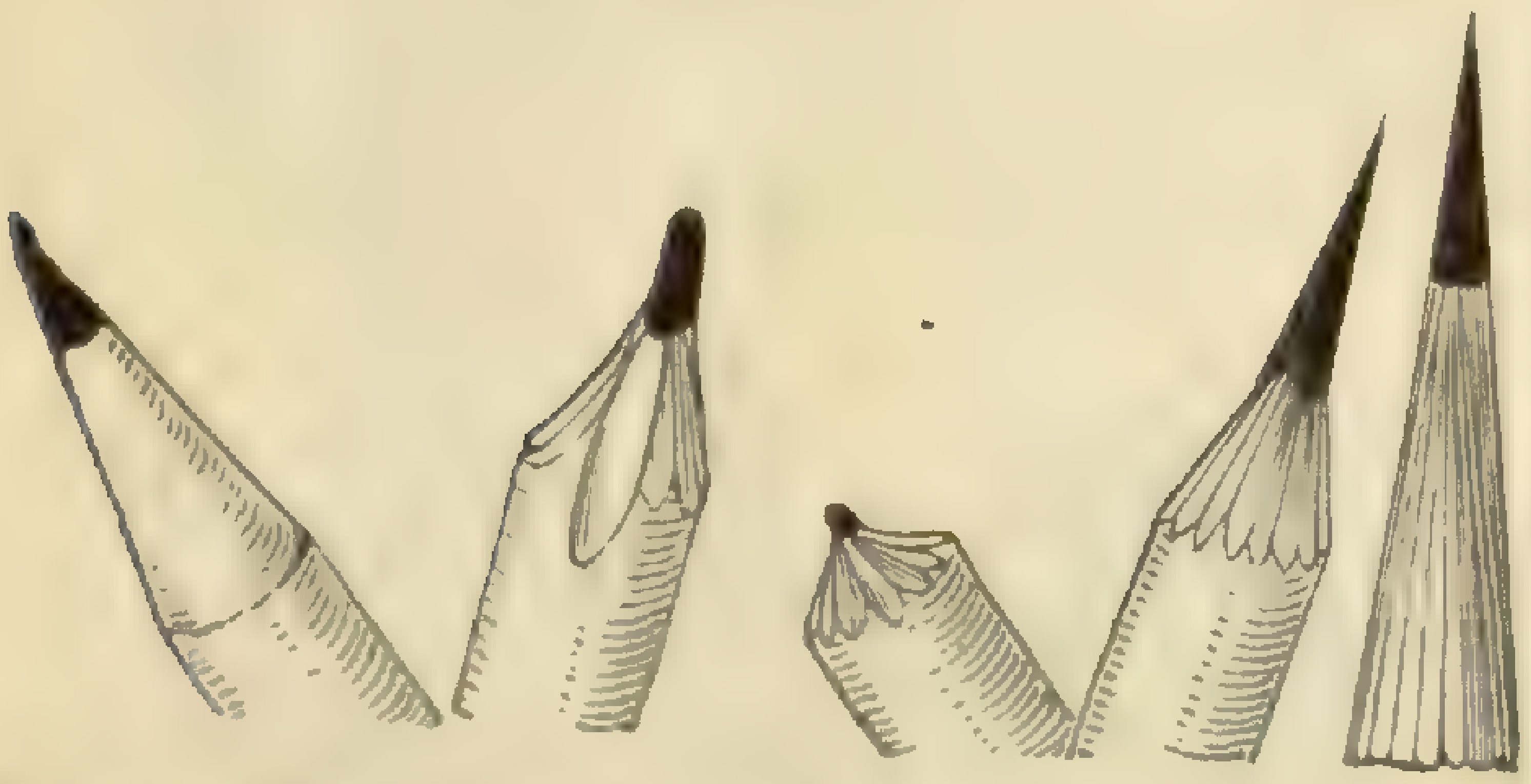

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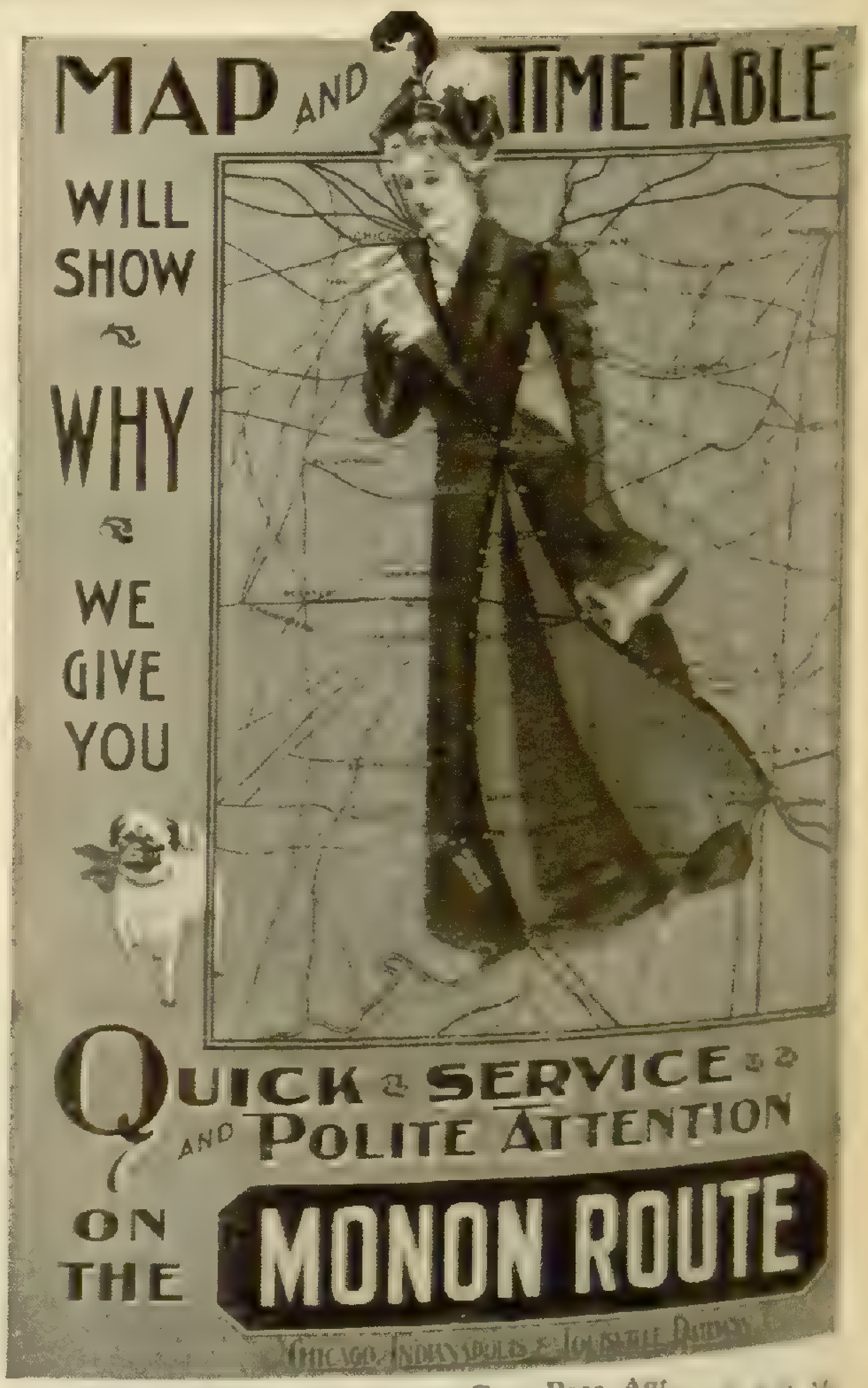
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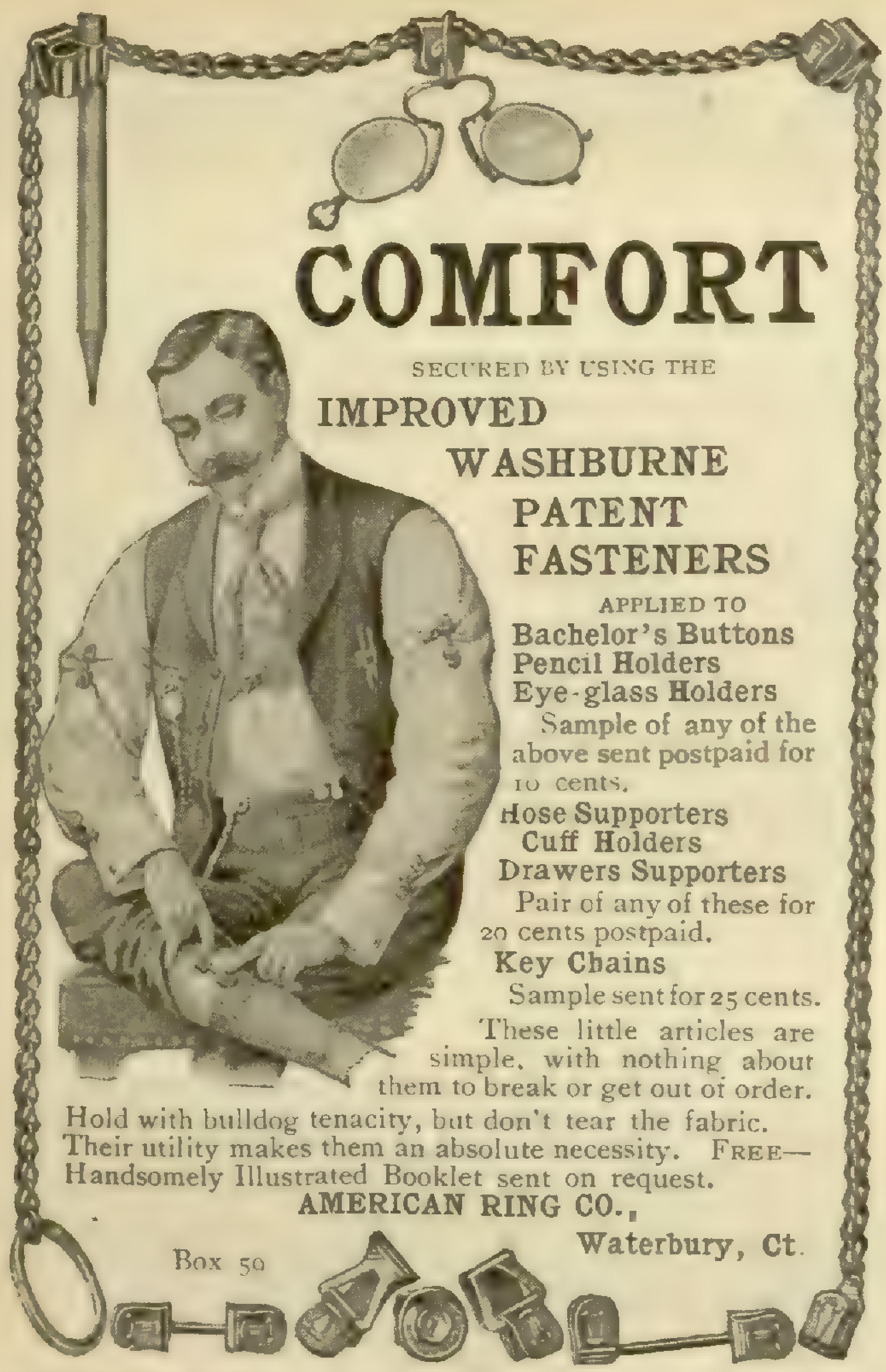

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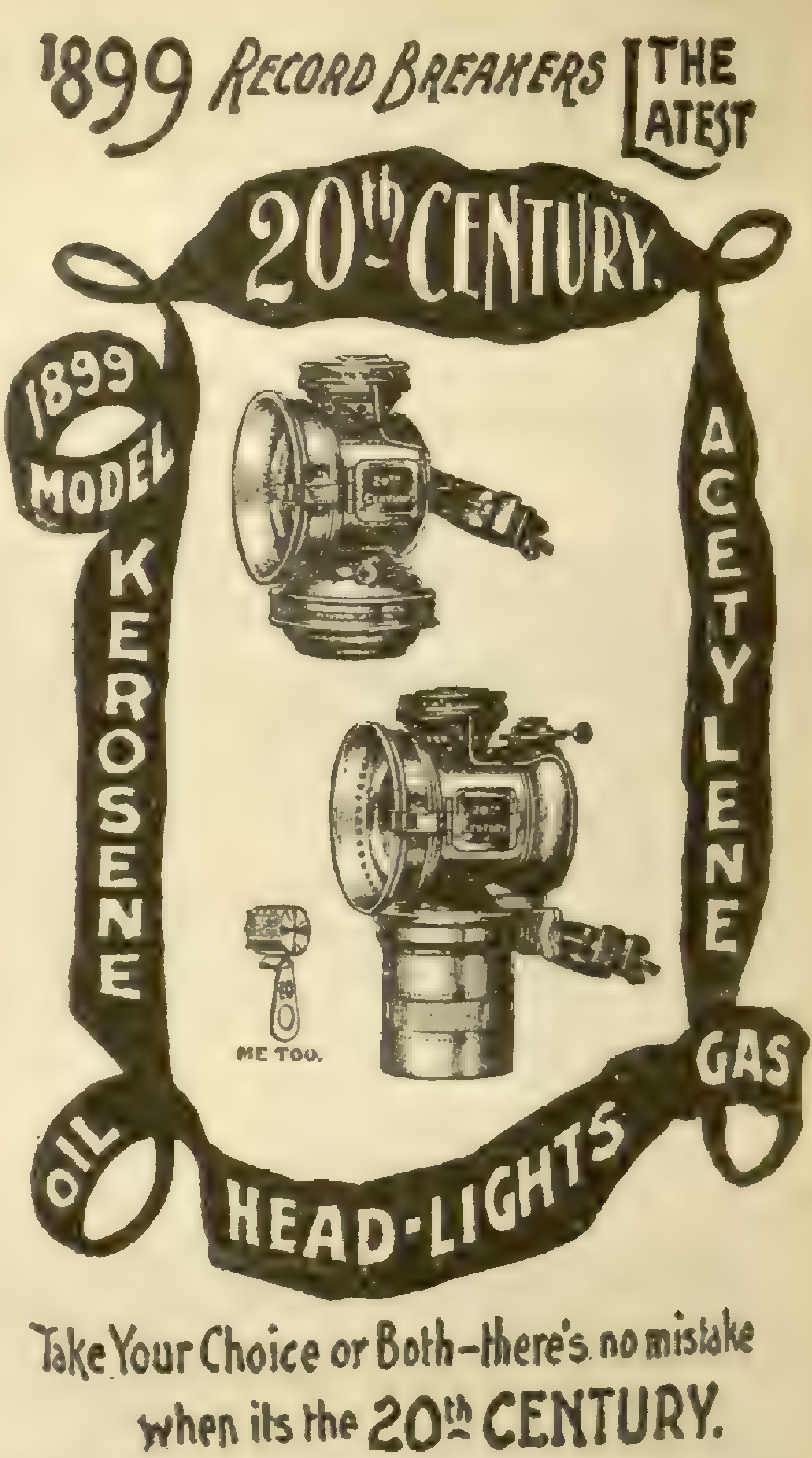

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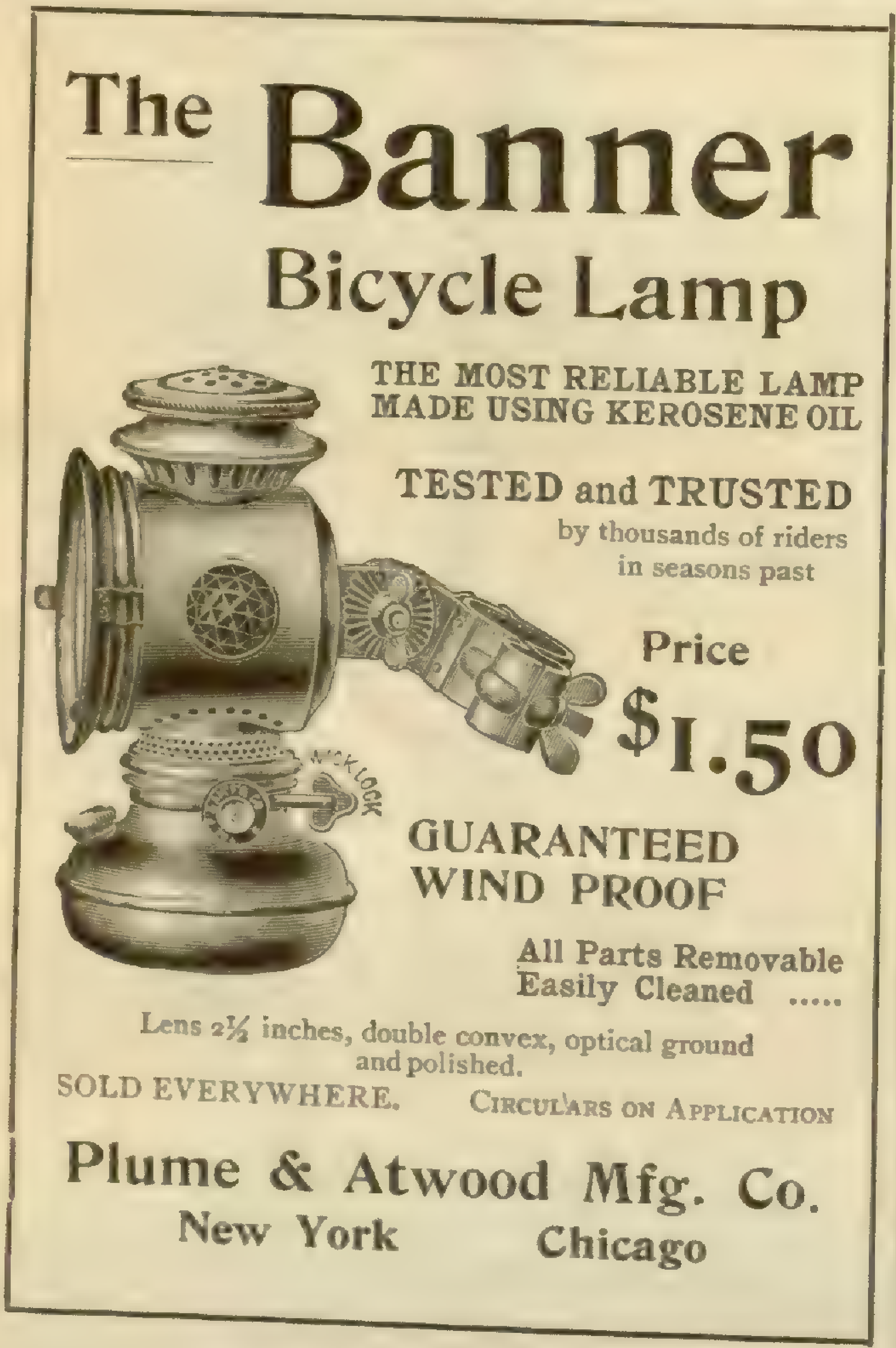

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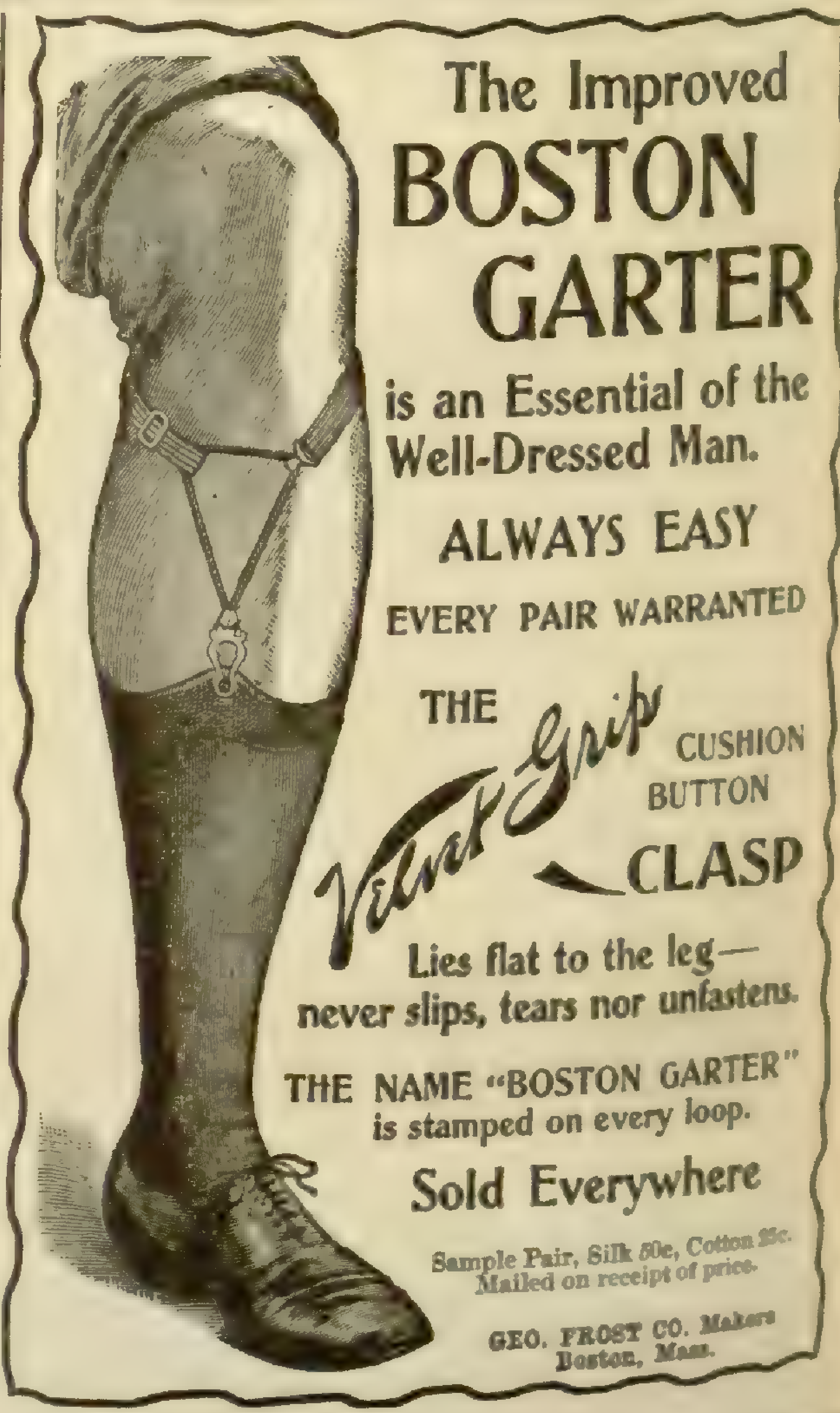

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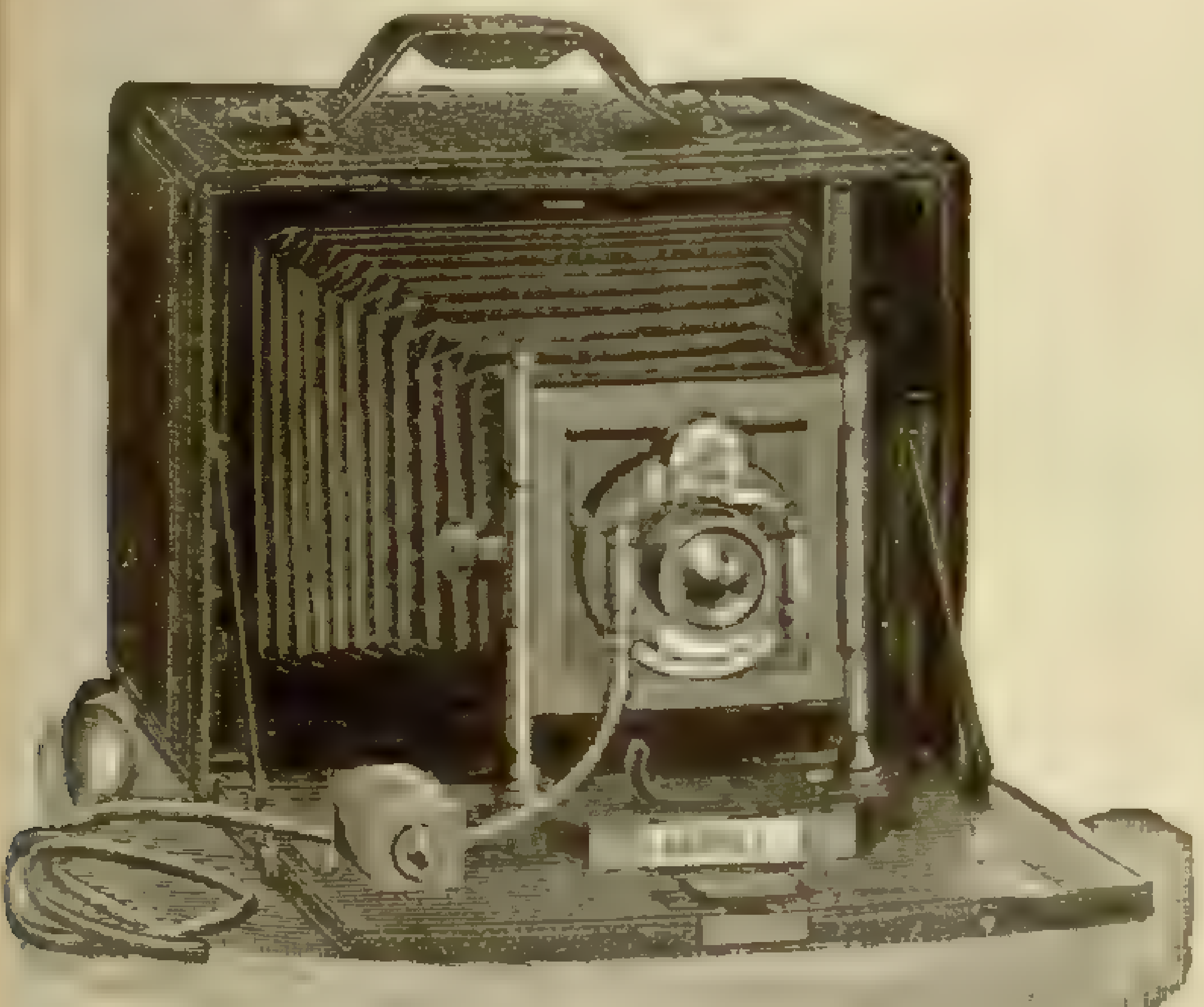

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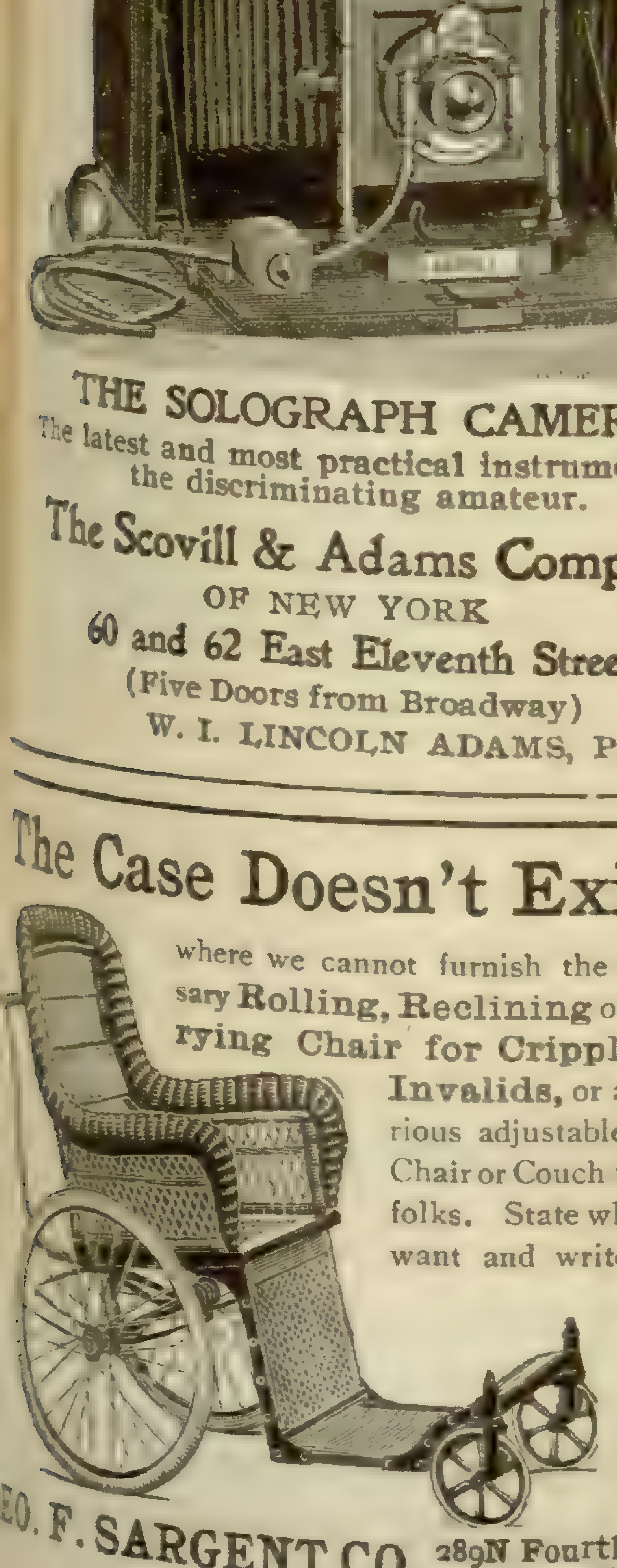

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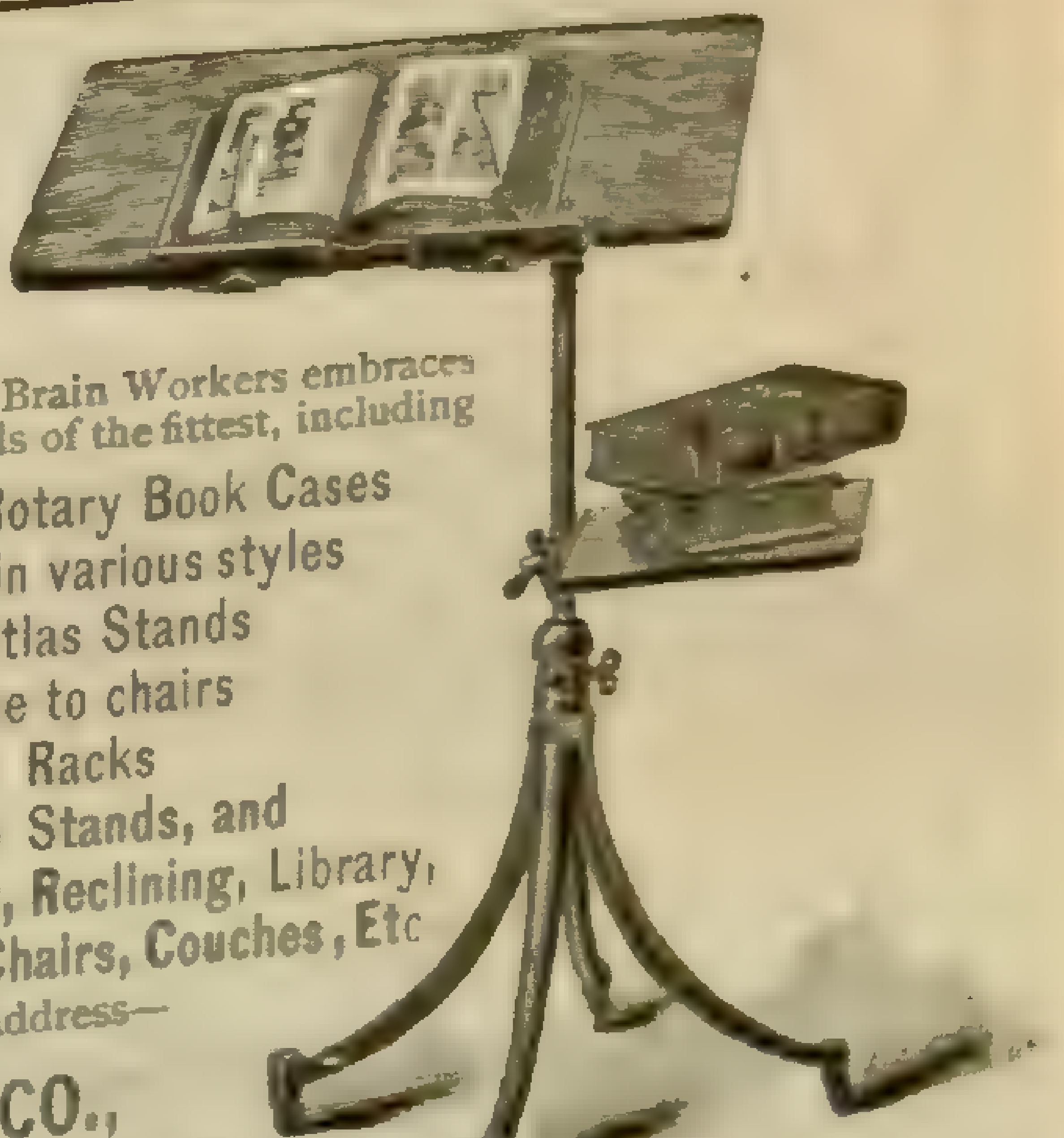

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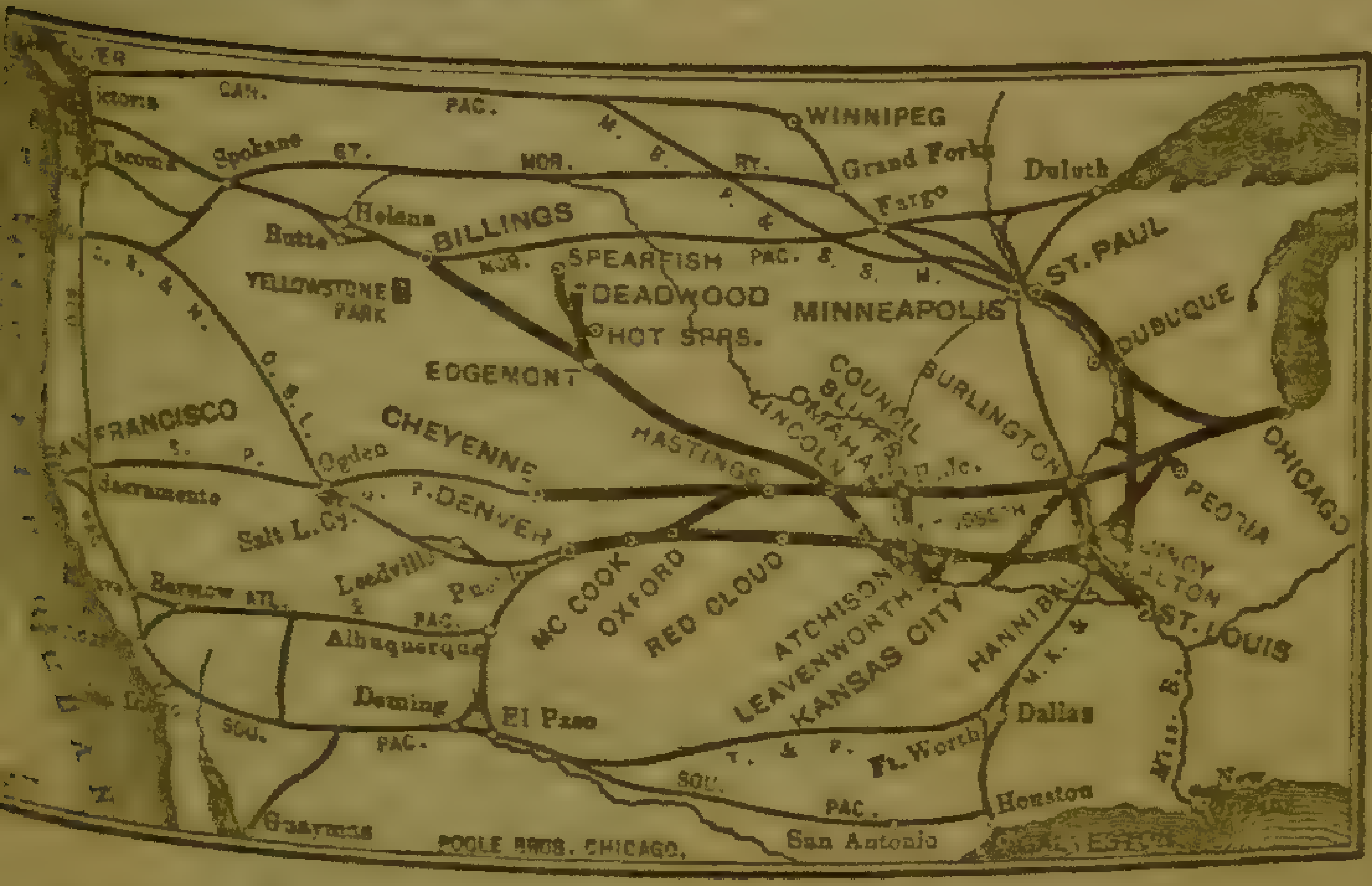
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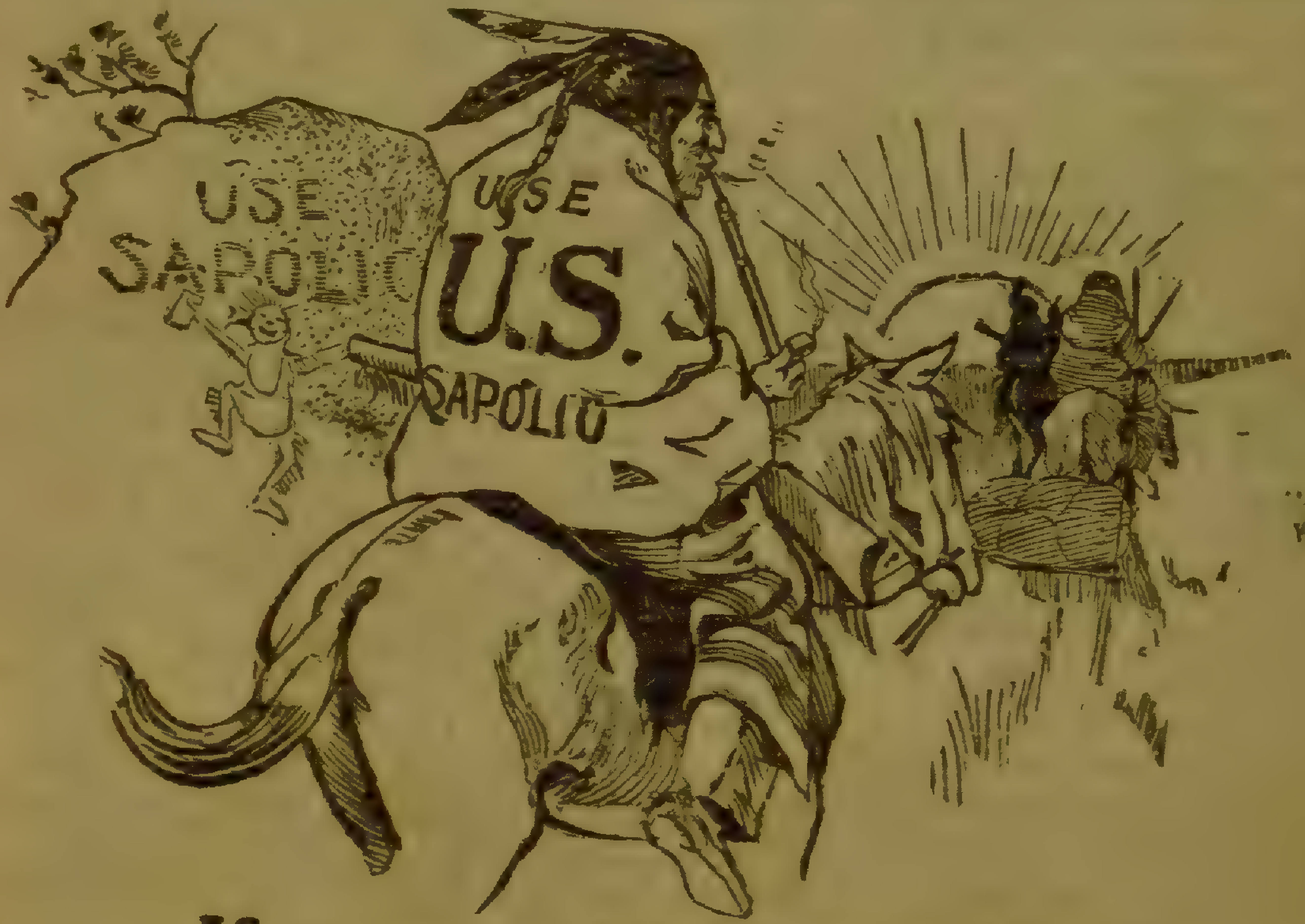

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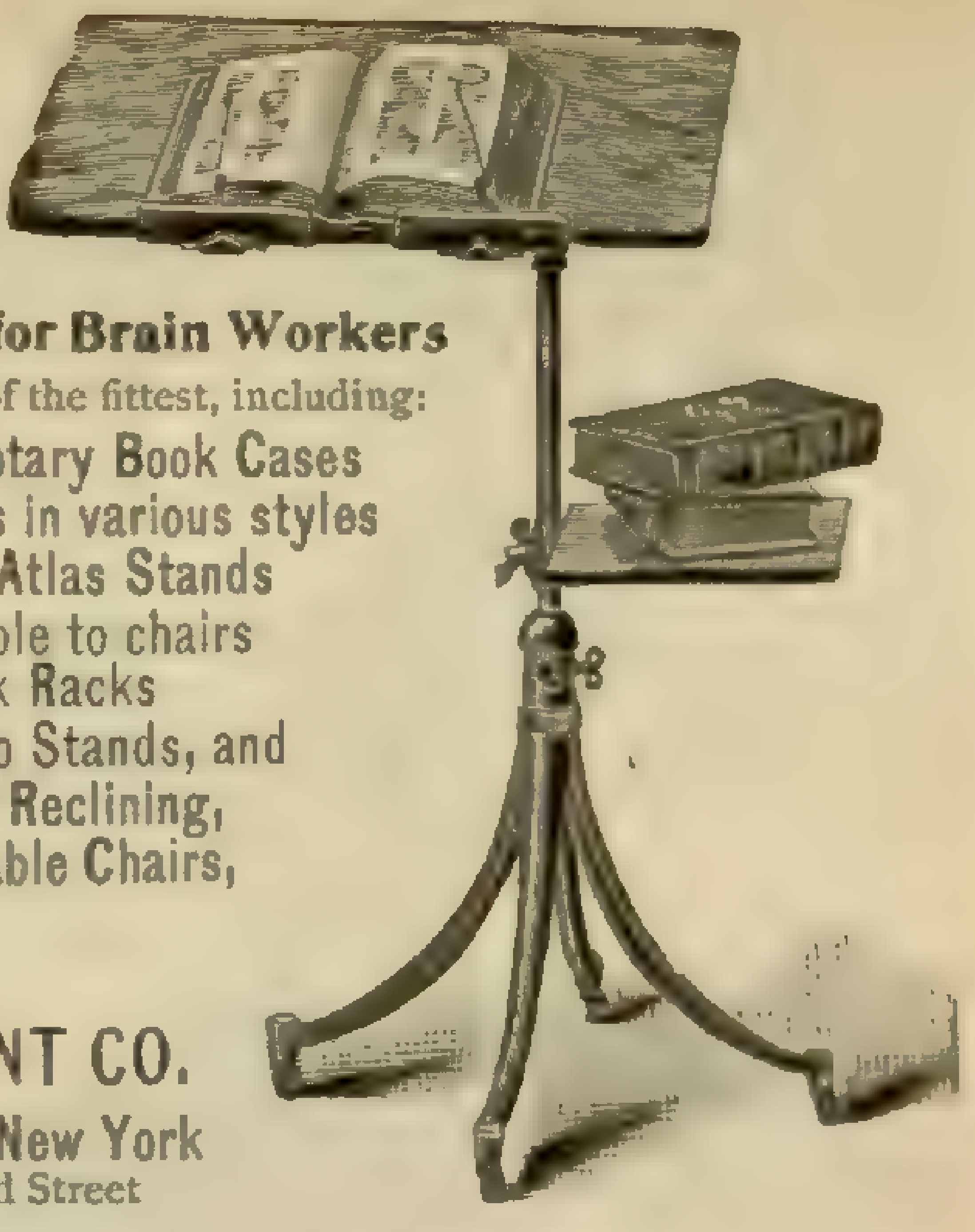

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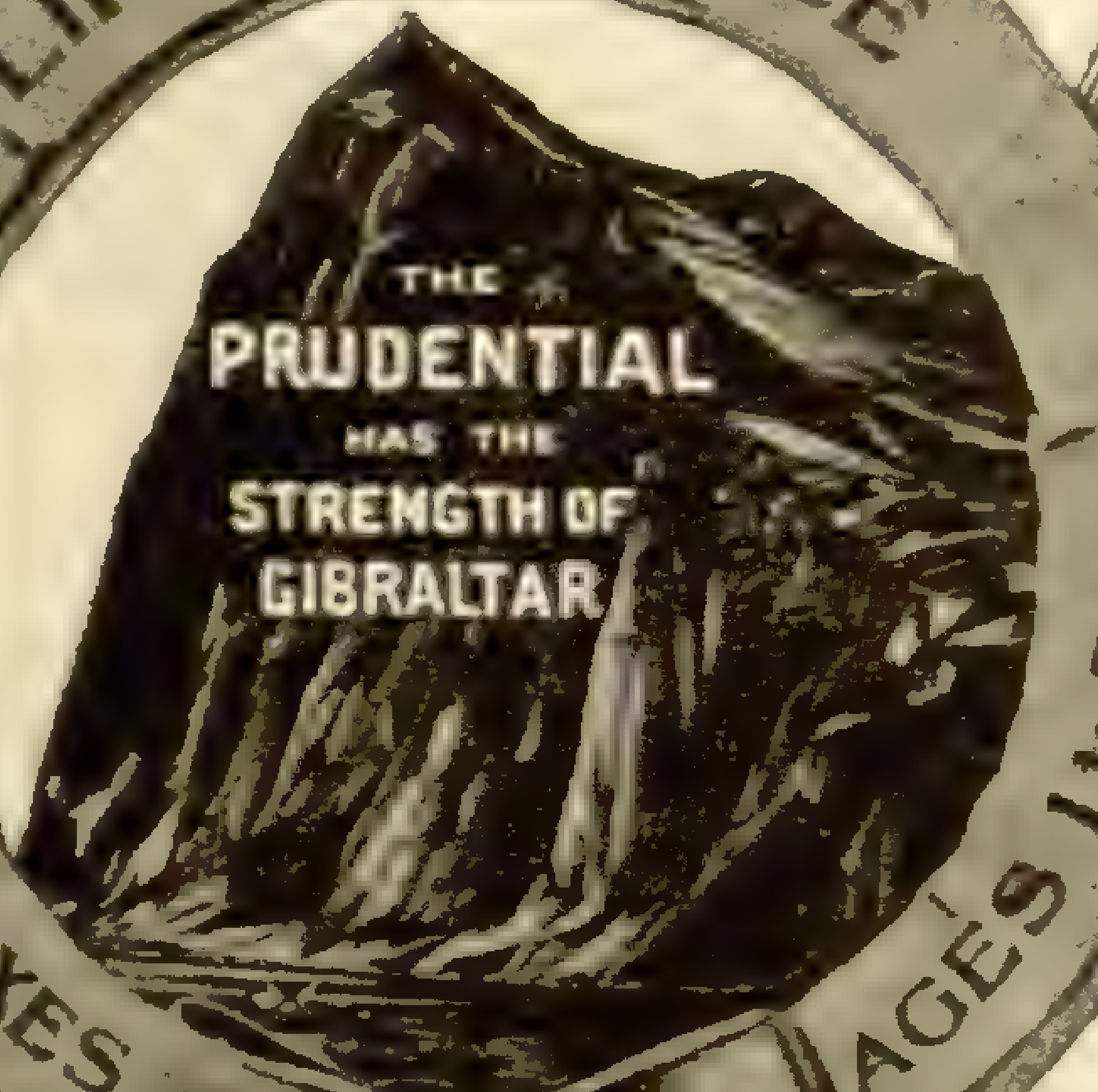
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VOLUME XXVII NUMBER 6

BOTANICAL GAZETTE

JUNE 1899

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A MORPHOLOGICAL STUDY.

THEO. HOLM.

(WITH FIGURES 1–10)

Podophyllum peltatum L., the *Anapodophyllon canadense* of Tournefort,[1] is a common inhabitant of the rich woods in the eastern parts of North America, ranging from Ontario to Florida and eastern Texas. On account of its social occurrence and very conspicuous foliage it is one of the most characteristic sylvan types of American vegetation. Outside of North America it has but three congeners: *Podophyllum Emodi* (Himalayas), *P. versipelle* (China), and *P. pleianthum* (China), which are the only species recognized by botanists, although Rafinesque described two others: *P. montanum* from the Alleghany mountains, and *P. callicarpum* from Louisiana and Texas. Judging from the description the last of these appears to be a good species, but has evidently not been collected by any one but Rafinesque.

While the genus is commonly regarded as a member of the Berberideæ it exhibits but very few characters common to the principal representatives of this order. It appears altogether as if the Berberideæ do not constitute a very natural order, even if we exclude Akebia and the other Lardizabaleæ. With Berberis as the type, it seems unnatural that this order should also comprise genera of such peculiar habit and structure as Podophyllum, Jeffersonia, Achlys and Diphylleia. At least Podophyllum shows several affinities with Actæa, and was placed next to it by Jussieu and St. Hilaire[2] under Ranunculaceæ. Another view was held by A. P. De Candolle, who placed the genus together with Jeffersonia and Achlys in his seventh order, Podophylleæ, referring Diphylleia to his Berberideæ, together with Berberis, Nandina, Leontice, Caulophyllum, etc. Baillon included Diphylleia under the order Podophylleæ. Lindley considered Podophyllum and Jeffersonia as representing a suborder, Podophylleæ, of the Ranunculaceæ. But the majority of the other authors seemed to have no difficulty in considering these genera as representing only one order, the Berberideæ. Even Asa Gray, who had better opportunities to examine the North American genera than anyone else, classified them all in the one order.

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[1] The derivation of Podophyllum, erroneously given in the *Synoptical Flora of North America*, p. 72, as "probably in reference to the very large footstock (!) of the radical leaves," depends evidently upon the abbreviation of its former name "Anapodophyllon" by Linnaeus. It is as stated by Tournefort "quasi planta cujus folia ad pedem Anatis accedunt," and the leaf-blade does show some resemblance to the web-foot of a duck. The reason why Linnaeus changed the name may be found in his *Critica botanica*, where similar generic names are abbreviated by "detruncatio capitis:" Oreoselinum = Selinum; Melocactus = Cactus; Anapodophyllum = *Podophyllum;* Hydroceratophyllum = Ceratophyllum.

It is true, however, that the floral structure of some of these genera shows certain analogies, as demonstrated by Bentham and Hooker, and more especially by Eichler in his comprehensive work, *Blüthendiagramme;* but there are, nevertheless, other points to be taken into consideration, as for instance, the structure of the vegetative organs, if not the very habit itself, which is exceedingly variable in these genera. In regard to *Podophyllum peltatum* very little has been published concerning its vegetative propagation, and nothing of its germination. These two phases of plant life seem to be very closely connected in the perennial herbs, inasmuch as the study of their seedlings has shown us that these, in many instances, give us a figure of the full-grown plant on a small scale. In this respect *Podophyllum peltatum* illustrates several points of interest, and we shall attempt in the present article to show the various stages of development which we have observed in this plant from seedling to flowering specimen, besides a few abnormal cases.

The seeds of *Podophyllum peltatum* germinate in the early spring, the cotyledons becoming visible by the end of April. At this stage (*fig. 1*) the seedling shows a well-developed primary root, *R*, and two cotyledons, the blades of which are folded around each other and borne upon long petioles, which are united to their full length so as to form a cylindrical, hollow tube. The plumule, *P*, is very minute and located at the bottom of the cotyledonar tube. *Fig. 2* shows another seedling at a more advanced stage, in which the cotyledons have become unfolded so as to show their final shape, broadly elliptical with the apex slightly emarginate. The primary root, *R*, has begun to branch with a pair of lateral roots, *r*, developed close beneath the plumule, *P*, and a few others farther down. The cotyledonar sheath, formerly bent in order to penetrate the ground, has stretched itself and is still enclosing the plumule. This last stage is maintained by the seedling during the first year, and when the cotyledons finally decay during the fall, the plumule shows no further development; hence the cotyledons are the only assimilating leaves of the plant during its first year of growth. A similar manner of germinating, with the plumule inactive during the first year, is also characteristic of *Hydrastis Canadensis* (Ranunculaceæ), but the petioles of the cotyledons are free, very long, and slender.

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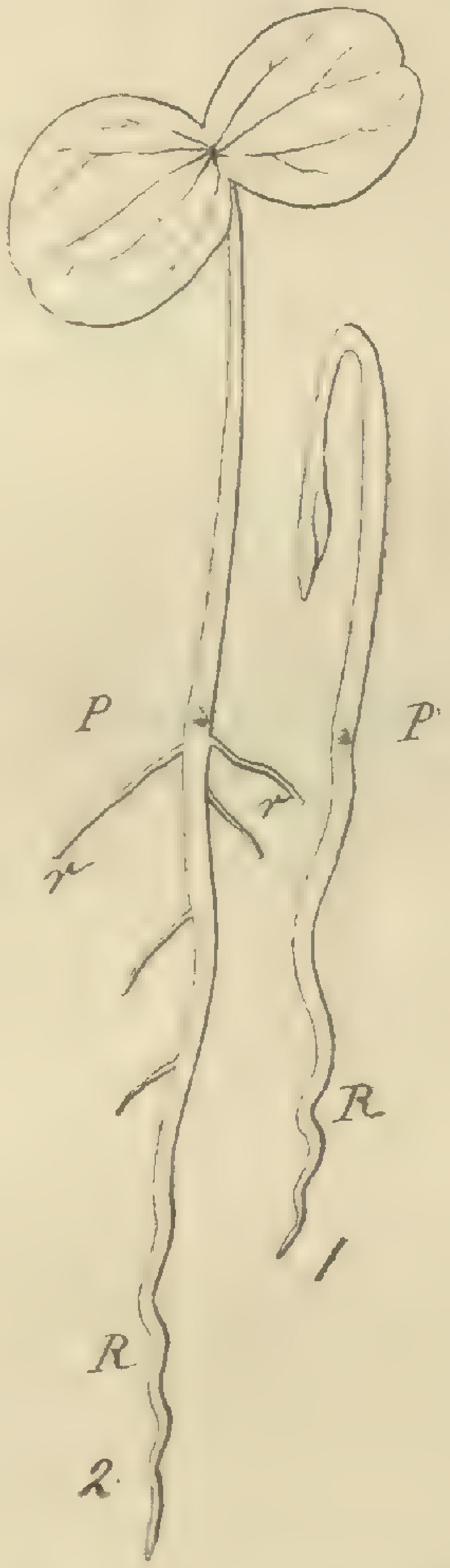
[2] For references consult the bibliography appended to this article.



FIGS. 1 and 2. Seedlings of *Podophyllum peltatum;* natural size. Explanation in text.

In *Podophyllum Emodi*, the germination of which has been studied by A. Dickson, the plumule may develop during the first season, and the first leaf is green, with a long petiole and peltate blade. No scale-like leaves are figured or mentioned. It is strange that Sir John Lubbock, who gives a similar account and illustration of *P. Emodi*, does not seem to have known of Professor Dickson's paper upon this subject, and we are almost inclined to believe that the early development of the plumule in *P. Emodi* was simply due to cultivation in a hot-house, and that both authors have overlooked the scale-like leaves. The manner of germinating which we have described as characteristic of *P. peltatum*, with its plumule concealed, makes it very difficult for the observer to discover such seedlings in their native haunts. The color of the cotyledons is, as we remember it, of the same light green as the foliage of this plant, and it is not uncommon to meet with these seedlings growing in dense clumps. It was this last circumstance that led the writer on the right track, when, some years ago, he was looking for seedlings of this plant, which grows abundantly in the vicinity of Washington. Bearing the fact in mind that the fruit of Podophyllum falls without bursting, and with the seeds closely imbedded in the gelatinous pulp, it was natural to suspect the light green seedlings which were growing in small clumps to belong to this genus, even though the plumule showed no signs of further development.

This type of germination, with the plumule inclosed in the tubular sheath formed by the union of the petioles, is not, however, characteristic of Podophyllum alone. In looking through the vast literature that deals with the germination of dicotyledonous plants, we find several instances recorded, which remind us of Podophyllum. Among the Berberideæ themselves, *Leontice Altaica* and *L. vesicaria* show a similar development of a cotyledonar tube, as described by Bernhardi; a larger number of cases have been observed in the Ranunculaceæ, viz., species of Anemone, Ranunculus, Delphinium, Aconitum, and Eranthis; in the Umbelliferae, viz., species of Ferulago, Prangos, Smyrnium, Bunium, and *Chærophyllum bulbosum;* besides these may be noticed *Megarrhiza Californica*, *Limnanthes Douglasii*, *Rheum Moorcroftianum*, *Polygonum Bistorta*, *P. viviparum*, and *Dodecatheon Meadia*. All these cases are somewhat similar to what we have described above for Podophyllum, but with the exceptions of Eranthis, *Aconitum Anthora*, and *Ranunculus parnassifolius*, the plumule develops during the first year, breaking through the base of the tube.

There is one point, however, by which *Podophyllum peltatum* seems to differ from the plants enumerated above, and this consists in the development of the first three leaves of the plumule as scales, the "Niederblätter" of the Germans. In all the other instances where a cotyledonar tube is developed, the first leaf of the plumule seems to be above ground, green, and of approximately the same outline as the later developed leaves. A very few cases are known from other genera, in which the first leaves are scale-like; for instance, *Hepatica triloba* and several species of Asarum, but the plumule is above ground in these, and the cotyledons are free. A very remarkable case is the germination of *Adoxa moschatellina*, which has been described by Alexander Braun. In this the cotyledons are above ground and free, but the plumule develops into a long internode under ground with scale-like leaves preceding the aerial green ones, thus agreeing to some extent with our *Podophyllum peltatum*. It is very interesting to observe the various ways in which the plumule is protected, especially when it is to hibernate in true bud form. But there does not seem to be any connection between the development of a cotyledonar tube and a naked plumule, *i. e.*, without scale-like leaves, nor between a hibernating plumule, surrounded by scale-like leaves, and free cotyledons, for in *Podophyllum peltatum* we find both; the plumule is here not only protected by the inclosing sheath of the cotyledons, but its first leaves, which are scale-like, furnish it ample protection during the winter.

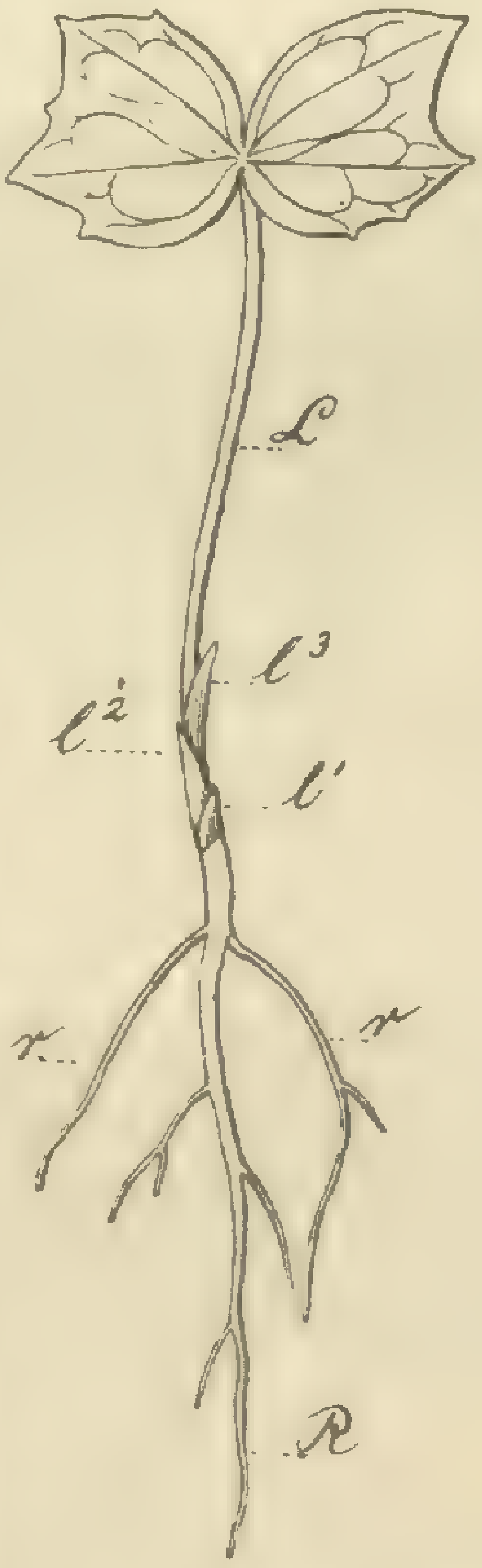


FIG. 3. Young plant of *P. peltatum* in its second year; natural size.

In continuing the investigation of the seedlings of Podophyllum, we noticed the following spring that the plumule had finally developed into a few very short internodes with scale-like, membranaceous leaves (*fig. 3*, l^1–l^3), and only one green leaf *L*, with long petiole and a blade of peltate shape. The primary root still persists, and the direction of the main shoot, the only one developed so far, is vertical. In comparing the plant at this stage with the seedling (*fig. 2*), we notice a striking resemblance to exist between the outline of the first proper leaf, *L*, and that of the united blades of the cotyledons. It seems as if the peltate form is already imitated by the cotyledons, which actually in this case represent but one leaf, when considered from a biological standpoint. This coincidence made us examine seedlings of other plants with peltate leaves, in order to ascertain whether the cotyledons of these might also imitate the shape of later developed stem leaves, but in those examined we failed to discover any that might be compared with Podophyllum. In *Menispermum Canadense*, for instance, the cotyledons are linear; in Tropaeolum the cotyledons remain under ground and inclosed by the seed-coat; *Hydrocotyle vulgaris* has small ovate cotyledons; and both Victoria and Nelumbium have their cotyledons remaining in the seed even a long time after germination has taken place.

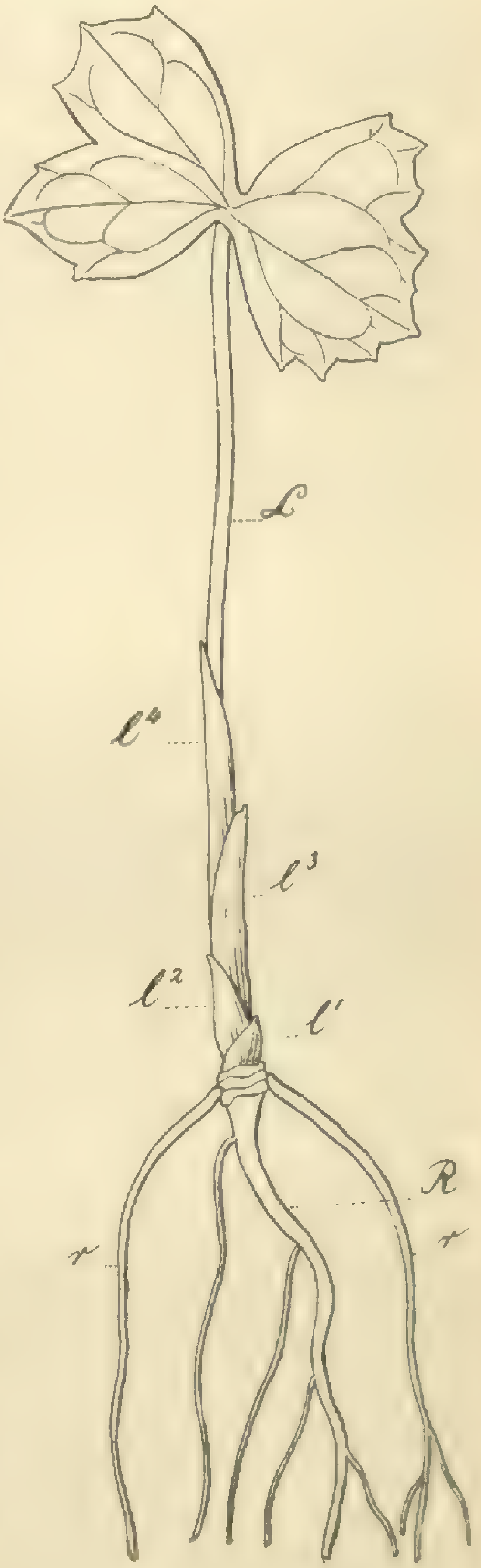


FIG. 4. Young plant of *P. peltatum* in its third year; natural size.

When the young plant of Podophyllum has passed the first two years of its existence, it sends up a long petioled leaf (*fig. 4, L*), with a blade that is considerably larger and more deeply lobed than the leaf shown in *fig. 3*. The development of a few scale leaves (l^1–l^4) preceding the green one is also noticed at this stage, and the primary root, *R*, still remains with an increased number of lateral roots. Besides these lateral roots the first pair of secondary roots, *r*, is observed to develop from the rhizome, which is here represented by the short internodes of the preceding year's growth, with scars remaining of the first scale leaves, l^1-l^3, and the first aerial green one, *L*. The direction of this little rhizome is still vertical, and the arrangement of the leaves is strictly alternate, in conformity with those of the previous year.

By examining the leaf axils of these two stages (*figs. 3* and *4*), we found no buds, excepting a very minute one in the sheathing base of the aerial leaf (*fig. 5*). This bud being terminal and the only one on the rhizome continues its growth for several years, developing successively a few scale leaves and a single green aerial one at the same time. It is not until the plant has reached an age of four or five years, that a lateral bud appears in the axil of one of the scale leaves and grows out as a horizontal shoot with elongated internodes. From this period the terminal bud of the mother-shoot ceases to grow, but remains dormant, and ready to push out should the lateral shoot become injured.

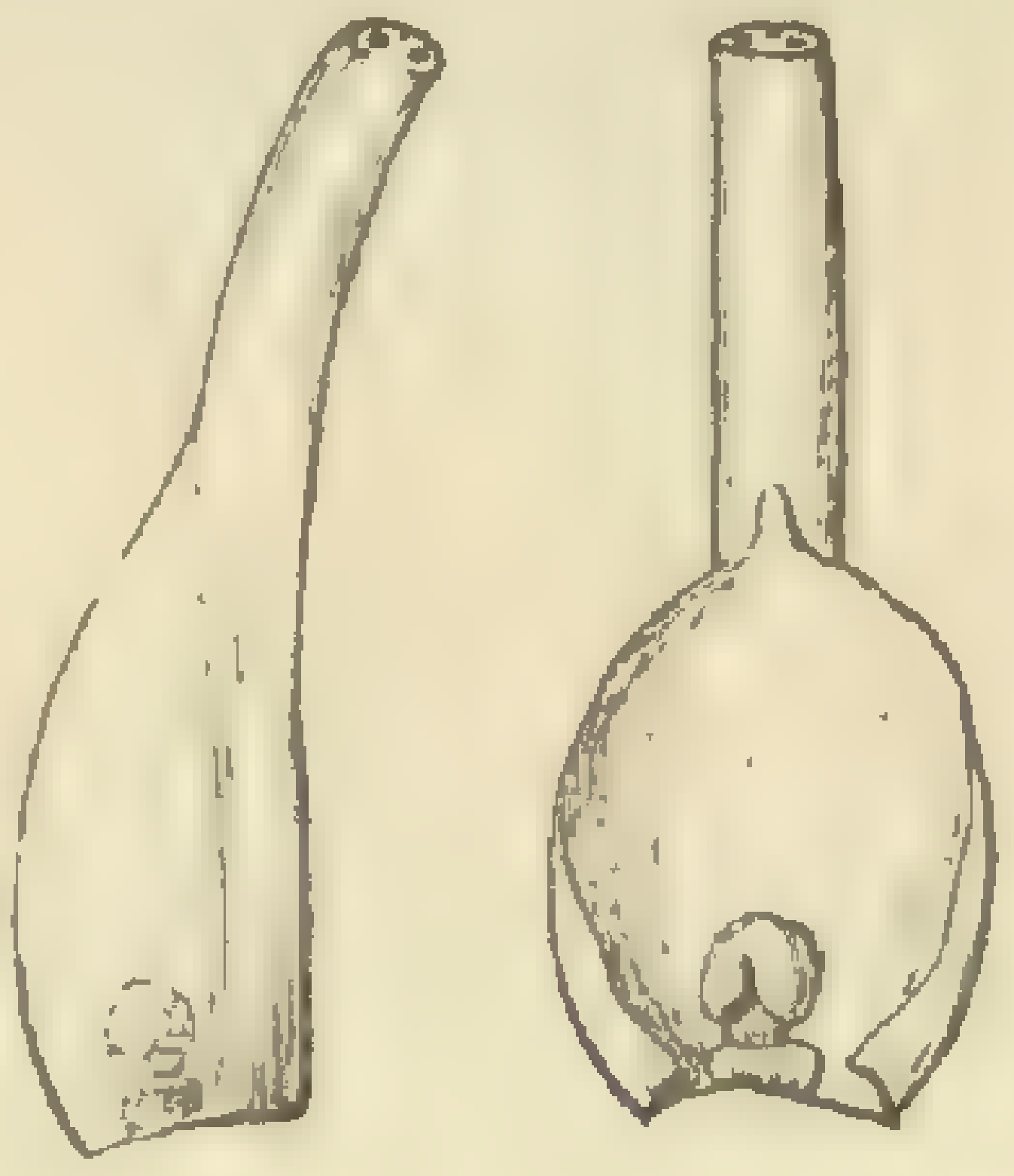


FIG. 5. Base of petiole of a leaf from a young plant; seen from the side and front; the sheath laid open to show the bud; magnified.

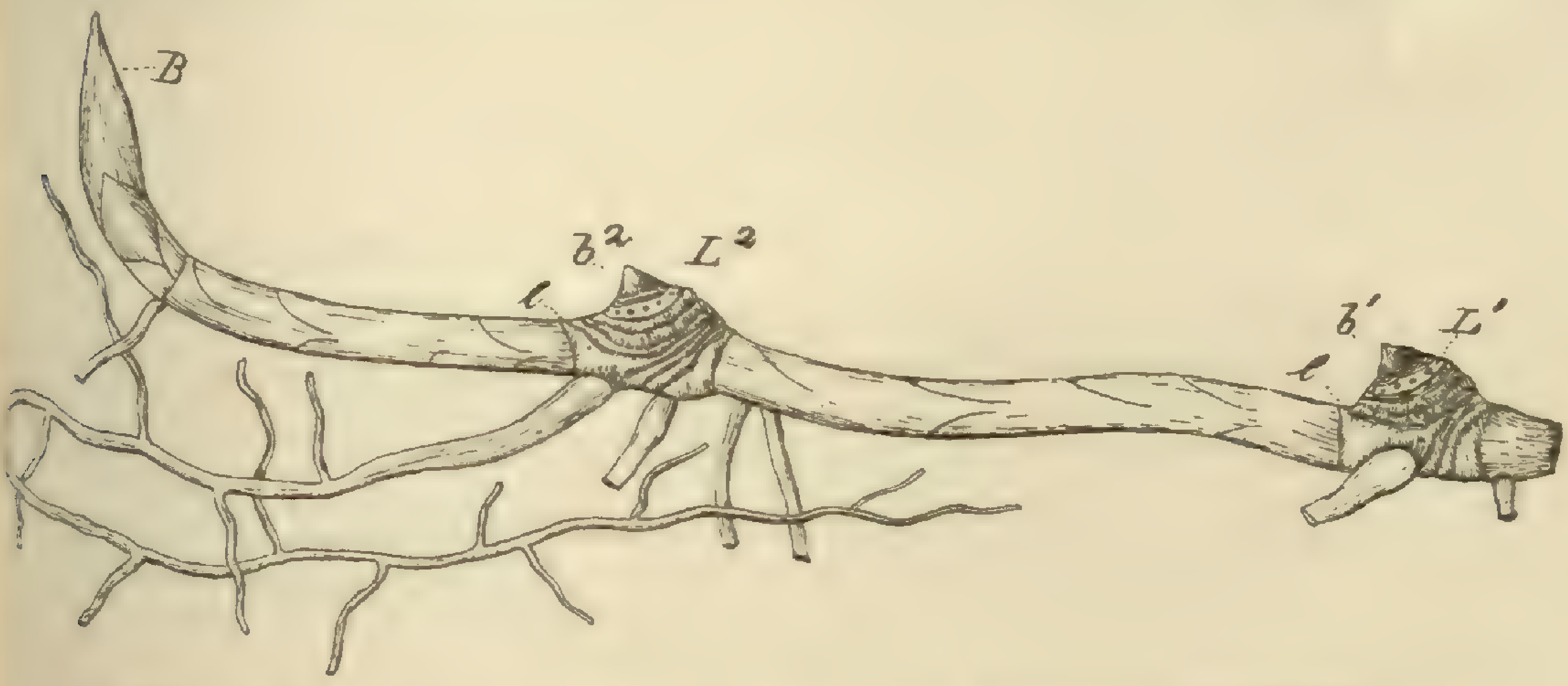


FIG. 6. Rhizome of full-grown specimen of *P. peltatum*; natural size.

When the lateral bud develops, the direction of the rhizome becomes changed from vertical to horizontal, and the original monopodium passes over into a sympodium. The accompanying figure (*fig. 6*) shows the rhizome of a mature plant, representing three years of growth: b^1 being the terminal bud from 1897, b^2 the corresponding one from 1898, while the large bud, *B*, the terminal one of the entire rhizome, will develop in the spring of 1899. L^1 and L^2 indicate the scars of aerial leaves borne upon shoots which are terminated by dormant buds, b^1 and b^2. The scars left from the scale leaves form narrow dark lines on the rhizome, but are very distinct on the short as well as on the elongated internodes. In the accompanying drawing of a joint of a mature rhizome of Podophyllum (*fig.* 7), the disposition of the leaves and buds may be seen more plainly. *Rh* and *rh* represent the anterior and the posterior parts of the rhizome; l–l^6 indicate the scars from scale leaves, while *L* shows the scar from a green leaf; *B* and *b* are buds, terminal and lateral; *r* and *r* are secondary roots.

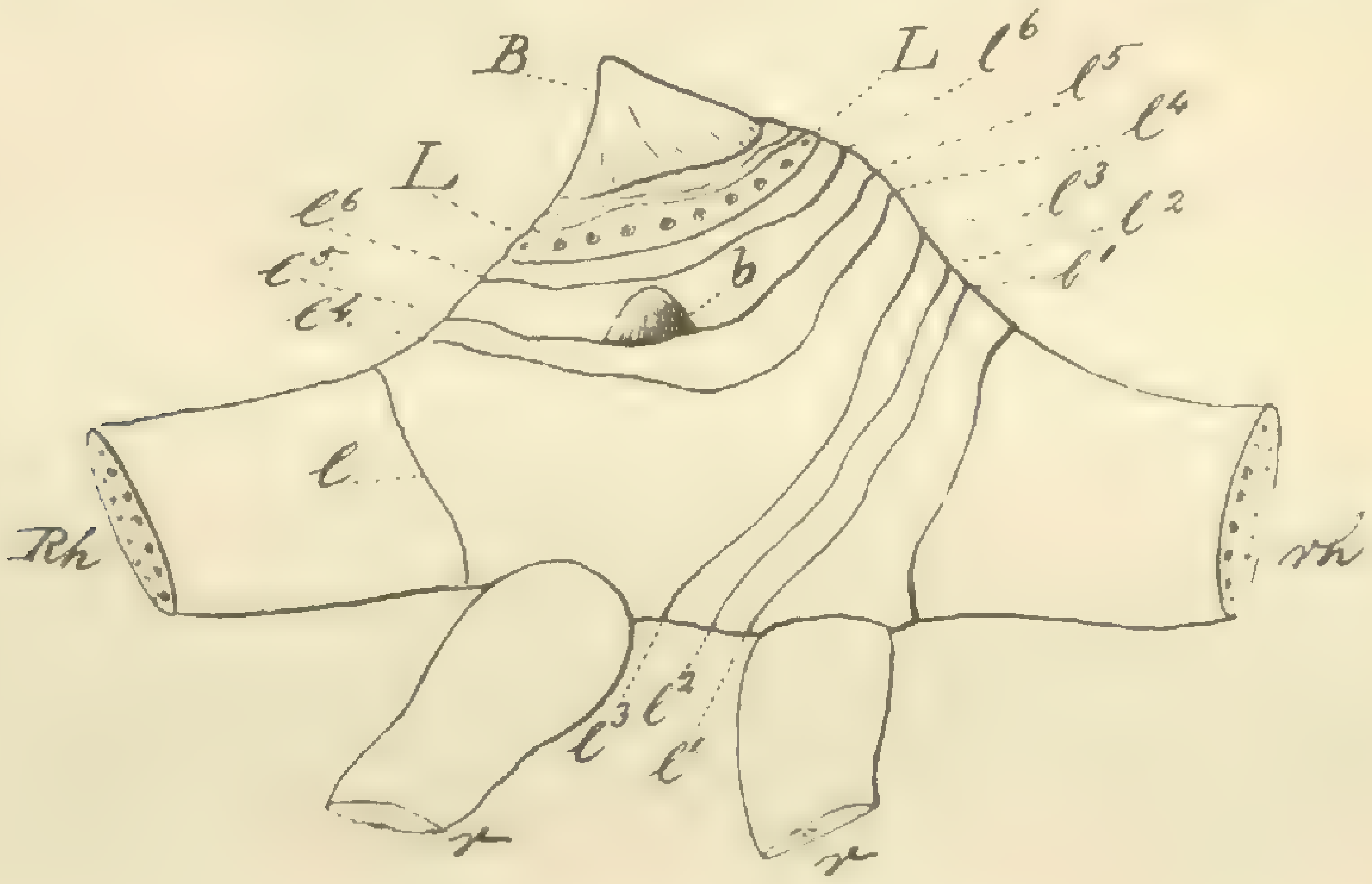


FIG. 7. Part of rhizome; magnified.

As we have stated above, the ramification of the rhizome is sympodial, a fact that is readily observed if we examine *fig.* 7. All the scale leaves, excepting the one marked *l*, are situated upon the same axis, terminated by the larger bud, *B*, which is purely vegetative and remains dormant. The anterior part of the rhizome, *Rh*, however, which bears a scale leaf, *l*, has developed from the axil of the scale leaf, l^3, in the same manner as the smaller bud, *b*, in the axil of the scale leaf, l^5. But while the smaller bud, *b*, seldom develops any further, the branch, *Rh*, grows out horizontally and in the same direction as the older part of the rhizome, as if it were the main axis itself. The entire rhizome thus represents a sympodium, composed of a series of shoots, each of which is terminated by a vegetative bud, *B*, and represents actually a monopodium.

In considering the arrangement of the leaves, we notice a very peculiar disposition. The diagram, *fig. 8*, is taken from a part of the rhizome corresponding to that shown in *fig. 7*, with the exception that instead of a green leaf, as at *L*, we have a flower-bearing stem with two leaves, L^1 and L^2, next to the terminal bud, *B*. All the leaves are alternate, but while the two outermost, l^1 and l^2, are situated to the right and left of the axis, the four innermost, l^3-l^6, are turned about 45° to the left of the median plane of the axis. Three buds are visible in this diagram, the terminal, *B*, and two lateral, b^1 and b^2, which are not strictly axillary, but have become pushed a little to the side, especially b^2. As stated above, the terminal bud remains dormant, while the bud, b^1, from the scale leaf l^3, grows out as a long, horizontal shoot, continuing the direction of the rhizome. The bud, b^2, which is developed in the axil of leaf l^5, also remains frequently dormant. While this structure, as shown in the diagram, *fig. 8*, appears to be the most common in our plant,[3] we have noticed, that some variations exist, *e. g.*,

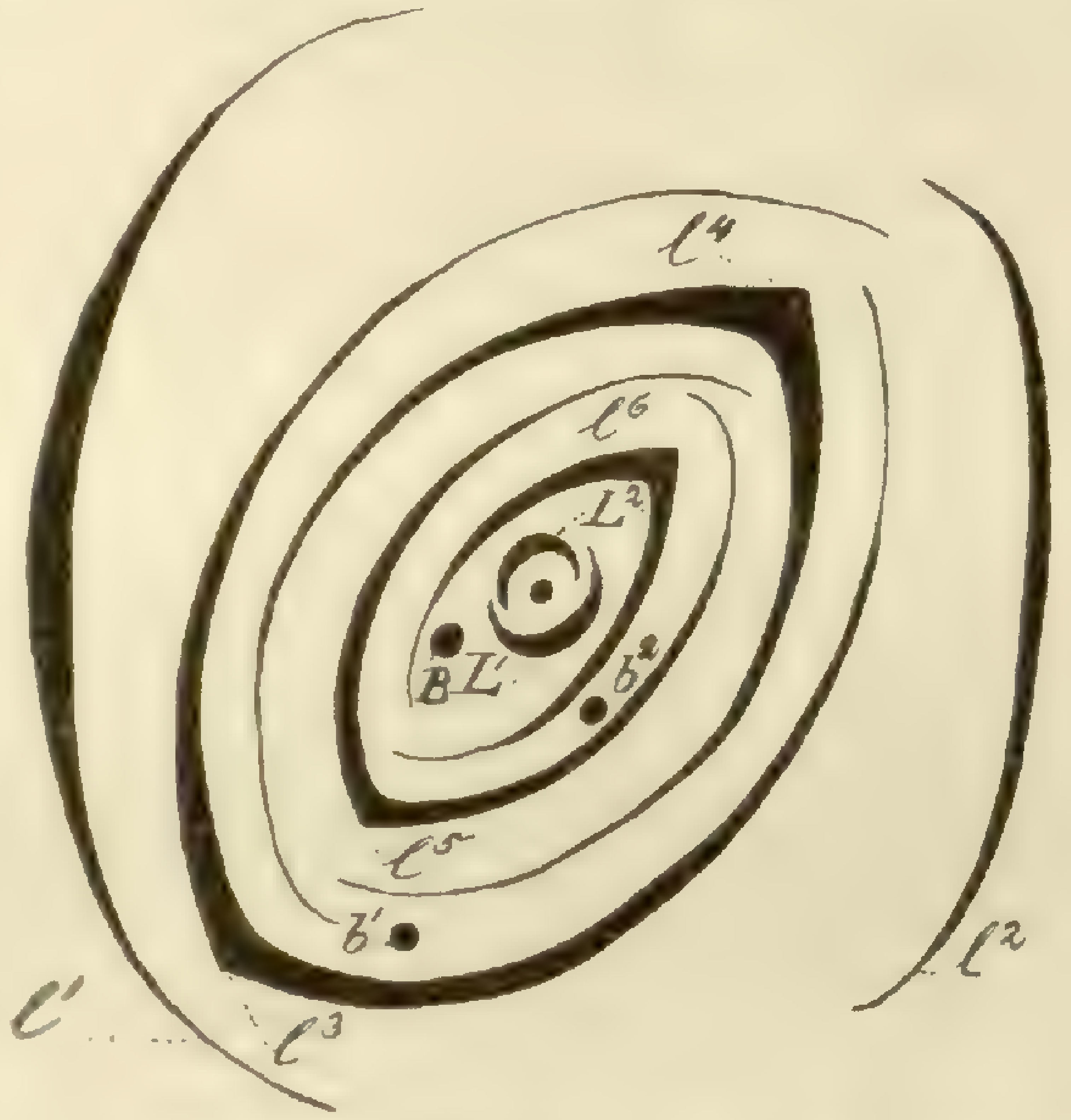


FIG. 8. Diagram of shoot of *P. peltatum*. *B*, terminal, b^1 and b^2 axillary buds; l^1-l^6, scale leaves; L^1 and L^2, the two green stem leaves.

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[3] By comparing Professor Schumann's observations with ours on the rhizome of *Podophyllum peltatum*, we have noticed several important discordances. Our very considerable and fresh material from the vicinity of Washington, D. C., showed, however, the structure as described above, and it may be that Professor Schumann's material, cultivated at Berlin, did not represent as typical development of buds and leaves as our specimens, grown wild in the native country of this plant.

an axillary bud may be developed from leaf l^4, instead of from leaf l^5. Also, a bifurcation is not uncommon, and this depends upon the non-development of the large bud, b^1, which is then replaced by two other buds in the axils of leaves l^4 and l^5, both of which are then situated to the right and left of the axis. These two buds develop simultaneously into two horizontal branches, with elongated internodes. Furthermore a bud may be developed in the axil of the leaf l^1, but remain dormant. When the large bud, b^1, becomes injured, two different cases were observed in which the rhizome nevertheless became able to continue its growth. Either a bud developed from leaf l^4, to grow out and replace the normal continuation of the rhizome, or the terminal bud, *B*, ceased to be dormant, developing into a horizontal branch. This last case is figured in the accompanying drawing (*fig. 9*). There are three relatively short internodes with scale leaves, terminated by a large bud, which contains a floral axis and some vegetative buds. The age of this branch is three years. The first internodes show a tendency to become stretched like those of the sympodial shoot when it develops. That the terminal bud became developed in this case was merely due to the injury of the shoot b^1, as is to be seen in *fig. 9*. A still more peculiar case may occur when the bud, b^1, does not grow out as a long branch, but as a few very short internodes, simulating the one described above.

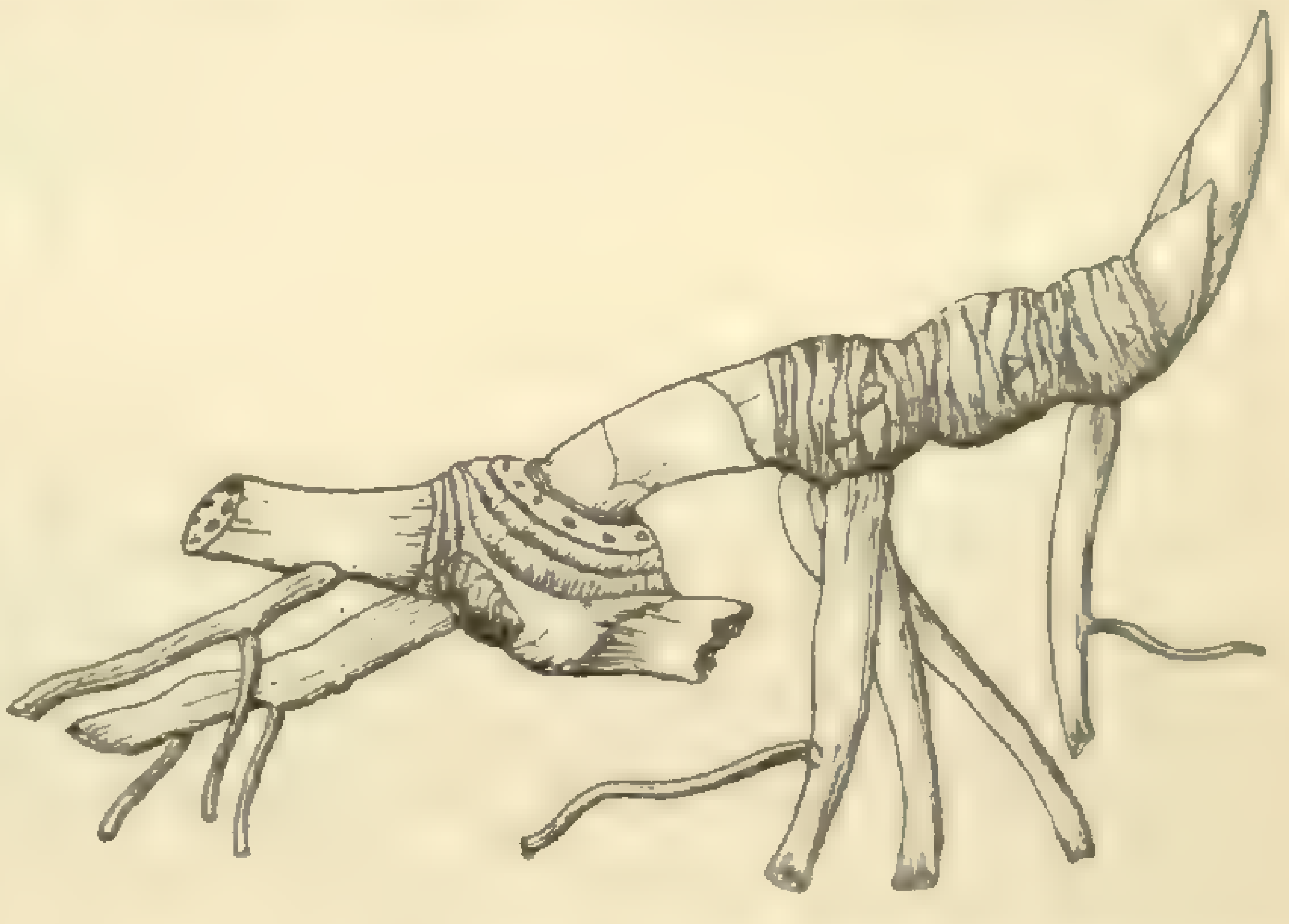

FIG. 9. Rhizome of *P. peltatum*; the terminal bud has grown out into a horizontal branch; natural size.

The development of these buds is, therefore, not restricted to any of the scale-like leaves, excepting the leaf, l^2; neither is their position constant, although the majority of cases examined show that a frontal position is the most common and naturally the most advantageous to the plant.

It now remains to mention the position of the floral axis.

The flower-bearing stem of *Podophyllum peltatum* develops exclusively from one of the short internodes of the rhizome, and is axillary, never terminal. It invariably develops, so far as noticed, from the axil of the leaf, l^6, while the terminal bud remains dormant at the base of its frontal part. By the continued growth of the flower-bearing stem, the terminal bud fuses with this and becomes almost imbedded in its basal portion. The two stem leaves, L^1 and L^2, are situated to the right and left of the flower, occupying a position that corresponds very well to that of two prophylla, as these occur in the dicotyledons, an explanation that has been proposed by Eichler (*l. c.*).

Concerning the structure of a floral bud, it is interesting to notice that sometimes one of the scale leaves may have a small peltate blade developed, as shown in *fig. 10*, *a*. The scale leaves are somewhat fleshy and surround the very minute flowering stem. Of its two leaves, the one is developed earlier than the other. The base of the petiole of this leaf is dilated into a pair of broad wing-like stipules, *St*, which overlap each other and enclose a very small green leaf and a flower bud (*fig. 10*, *b*); thus the two green leaves of Podophyllum did not develop at the same time, as it might seem, when we examine the plant during its flowering period with the leaves apparently opposite.

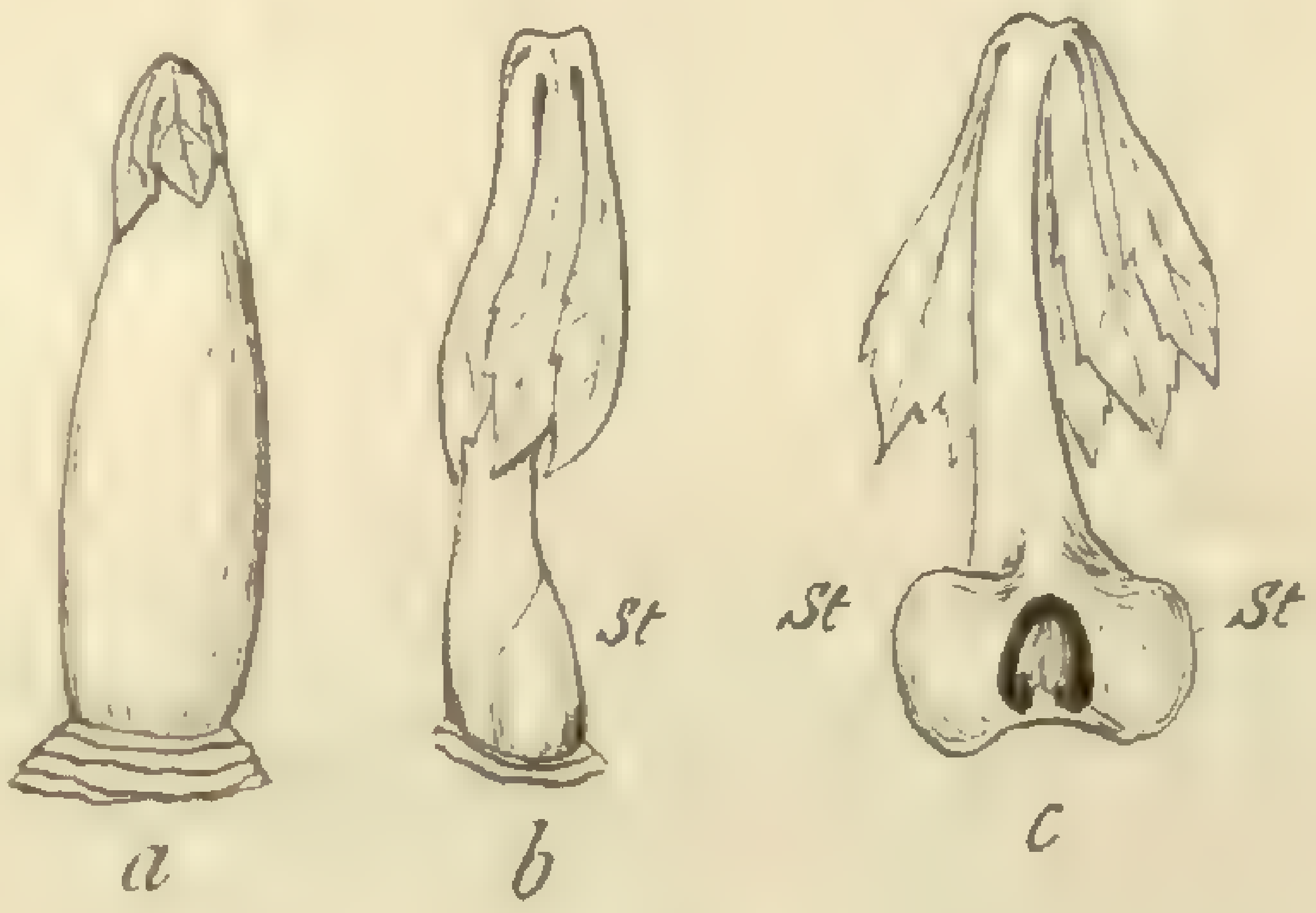

FIG. 10. *a*, scale leaf with small peltate blade; *b*, first stem-leaf enclosing the second one in its basal sheath; *c*, same, the sheath laid open to show the enclosed leaf and flower-bud; magnified.

The roots are very strong and somewhat thickened. They develop exclusively from the short internodes of the rhizome, close to the lower surface, from which they proceed horizontally close to the surface of the soil.

The anatomy of *Podophyllum peltatum* in some respects resembles that of the monocotyledons more than it does that of the dicotyledons. De Bary has, therefore, classified Podophyllum among anomalous dicotyledons, in which the mestome bundles of the aerial stem are not arranged in concentric bands. It is strange to notice that Podophyllum has this feature in common with Diphylleia, Leontice, and various species of Papaver, Thalictrum, and Actæa.

A transverse section of the stem above ground shows a thin walled epidermis and a cortical parenchyma that passes over into the large pith, both of which consist of thin walled cells of nearly the same size. The mestome bundles form three irregular bands, the two inner ones being located in the pith, and represent various stages of development. Very characteristic is the structure of the leptome, in which we notice no other elements than sieve tubes and their companion cells, while cribral parenchyma is totally absent. In this respect Podophyllum agrees with the monocotyledons and the Ranunculaceæ only among the dicotyledonous orders. The hadrome consists of a number of vessels arranged very close to each other, and a well developed cambium is noticeable between this part of the mestome bundle and the leptome. Stereome forms closed rings around the mestome bundles; it is especially thick walled on the leptome side.

By comparing the structure of the stem above ground with that of the rhizome, the following divergences were observed: The mestome bundles form only a band, and that an almost regular concentric one, with only a few small bundles lying outside in the cortex. The vessels are very thick walled. While the cortex and the pith show approximately the same development as in the aerial stem, the outer layers of the cortical parenchyma show a very pronounced thickening of the cell walls, like those of collenchyma. Sheaths of thin walled stereome surround the mestome bundles without forming connecting layers between them.

The structure of the petioles of the stem leaves shows a very irregular distribution of the mestome bundles. There is here, as in the aerial stem, an almost regular peripheral band, located in the cortex; but inside this, in the pith, the mestome bundles are scattered very irregularly. The cylindrical petiole of a young leaf, developed from the rhizome, has only four peripheral mestome bundles in the cortex, and one in the center of the pith. Corresponding with the stem above ground, the mestome bundles of the petioles are supported by sheaths of quite thick walled stereome, especially on the leptome side.

Characteristic of the root is the strong thickening of the outer walls of the epidermis, even in roots of very young specimens. The cortex is solid, with no lacunae, and the innermost layer is differentiated into a thin walled endodermis. Five groups of vessels alternate with a corresponding number of leptome groups, bordering on the pericambium, and the innermost part of the central cylinder is occupied by a thin walled conjunctive tissue.

In considering these anatomical peculiarities, especially the structure and arrangement of the mestome bundles, it cannot be denied that Podophyllum possesses a very anomalous internal structure. The morphological characteristics which have been discussed above, the manner of germinating, and the peculiar ramification observable in the rhizome are seldom met with in dicotyledonous orders; and the creeping rhizome with its monopodial shoots reminds us very much more of the monocotyledons.

Hence, when the "mesophytes," to which our plant is said to belong, have been characterized as possessing "no very pronounced or interesting features in anatomical or morphological respects," the statement does not seem applicable to *Podophyllum peltatum*. Neither does it hold true if we examine the other herbs that constitute the vegetation in the deciduous forests of North America. Many of the herbaceous species which are generally associated with Podophyllum show morphological peculiarities that are very conspicuous and characteristic. It would, indeed, be difficult to point out a vegetation in this country that contains a larger number of herbs with as varied and interesting morphological structure as our forest plants, lately classified simply as "mesophytes." *Podophyllum peltatum* prefers the wooded belts in this country, and its nearest associates, those that occupy the same kind of soil and grow in company with it, are, strange to say, just the genera that were once considered as representing a little natural group of plants: Diphylleia, Jeffersonia, Caulophyllum, Actæa, and Cimicifuga. These strikingly resemble one another in habit; moreover, they possess a number of biological peculiarities that might even lead to a more correct understanding of their true relationship than such small and insignificant floral characters as are used for the establishment of "orders." By taking the habit into consideration, we may sometimes reach a simple but much more natural idea of the plant and its nearest allies.

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—— Anomale Keimungen. *Ibid.* **36**: 127.

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXI.

JOHN DONNELL SMITH.

[*Concluded from p. 339.*]

Ardisia Palmana Donn. Sm.—Glabra. Folia subsessilia opaca subimmaculata integra oblongo-lanceolata e medio utrinque praesertim superne acute angustata. Paniculae terminales vastae floribundae, axibus alternis divaricatis, floriferis brevibus ad apicem versus subcapitato-floris. Calyx basi producto sessilis partitus, segmentis orbicularibus tubum corollinum paulo superantibus quam lobi ovales dimidio brevioribus. Antherae filamentis fere aequilongae.

Arbor, coma globosa (Tonduz in schedulis). Folia 1.5–3^{dm} longa 3.5–8^{cm} lata in petiolum brevissimum marginatum desinentia subtus pallidiora et obscure nigro-punctata, nervis approximatis. Paniculae folia aequantes folioso-bracteatae, axe flexuoso, ramis glanduloso-puberulis, inferioribus 1.5–2^{dm} longis, floriferis 5–10^{mm} longis, floribus arcte confertis 5–meris totis pallide roseis parce nigro-punctatis, bracteolis lanceolatis 1^{mm} longis. Calycis segment adextrorsum obtegentia 1.5^{mm} longa ciliatula basin crassum obpyramidatuma equantia. Corollae 4^{mm} longae lobi dextrorsum convoluti 2^{mm} lati. Stamina prope basin corollae affixa 4^{mm} longa, antheris sagittato-lanceolatis longitudinaliter dehiscentibus. Ovarium diam. 1 millemetrale, stylo 3^{mm} longo. Fructus ignotus.

In sylvis prope La Palma, Costa Rica, alt. 1460^{m}, Sept. 1898, *Tonduz*, n. 12632 herb. nat. Cost.

Ardisia spicigera Donn. Sm.—Glaberrima. Folia coriacea oblanceolata acutiuscula in petiolum brevissimum longe angustata integerrima. Spicae interrupte densiflorae paniculam terminalem formantes, floribus ebracteolatis. Filamenta filiformia, antheris parvis.

Folia decurva 10–15^{cm} longa 3–5^{cm} lata opaca subtus squamulis fuscis ope lentis tantum conspicuis conspersa, costa nervisque supra immersis, petiolis 3–5^{mm} longis. Paniculae ramos terminantes folia superantes, axibus angulatis, secundariis suberecto-patentibus 6–10^{cm} longis plerumque simplicibus, floribus aggregatis aut passim solitariis 5-meris parce lineato- et puncto-maculatis, alabastris ovoideis. Calycis partiti segmenta orbiculari-ovata obtusa 2^{mm} longa ciliata extus in medio rugulosa intus prope basin aureo-papillosa. Corollae tubus 2^{mm} longus, lobi dextrorsum obtegentes oblongi 3^{mm} longi obtusi. Filamenta basi dilatata 3^{mm} longa, antheris sagittato-triangularibus apiculatis 1^{mm} longis apice biporosis. Ovarium globosum 1.5^{mm} diam., stylo 5^{mm} longo. Fructum non vidi.

Comitan, Chiapas, Mexico, Aug. 1896, *Seler*, 2678.

Prestonia speciosa Donn. Sm.—Fusco-velutina. Folia discoloria supra parce pubescentia ovalia cuspidato-acuminata basi obtusa. Cyma umbelliformis pedunculata, floribus maximis. Calyx pedicello aequilongus. Corolla usque ad mediam fissa, tubo supra medium sensim ampliato calycem bis superante esquamato, lobis dolabriformibus. Antherae inclusae.

Stipulae interpetiolares utrinsecus circiter 8 setaceae 3^{mm} longae glabrae stramineae. Folia 16–21^{cm} longa 9–13^{cm} lata, nervis lateralibus utrinque 8–10, petiolis 1–1.5^{cm} longis. Pedunculus 5–8^{mm} longus, pedicellis 5–9 aequalibus 1.8^{cm} longis, bracteis lanceolatis 1^{cm} longis, alabastris fusiformibus 6^{cm} longis, 1^{cm} latis. Calycis segmenta oblongo-ovata, squamae truncato-deltoideae superne glabrae et stramineæ paucidentatae denique setaceo-laceratae. Corollae tubus 3.6^{cm} longus ad ⅔ longitudinis staminigerus, fauces superne 1.5^{cm} latae et plica 2^{mm} lata instructae, lobi glabri valde inaequilateres 2.5^{cm} lati. Filamenta 3^{mm} longa, antheris 8^{mm} longis. Disci partiti segmenta dentata ovarium paulo superantia, carpellis glabris semiorbicularibus 1.5^{mm} altis. Folliculi non suppetunt.

Buena Vista, Depart. Santa Rosa, Guat., alt. 1700^{m}, Apr. 1893, *Heyde et Lux*, n. 4497 Pl. Guat. etc., qu. ed. Donn. Sm.

Forsteronia myriantha Donn. Sm.—Fusco-pubescens. Folia opaca supra glabrescentia subtus ad nervos pubescentia denique glabra oblongo-elliptica acuminata mucrunculata basi acuta, inferiora minora elliptica utrinque obtusa. Cymae in thyrsum terminalem pedunculatum ovoideum compactae, floribus corymboso-fasciculatis inter minores pedicellos vix ac ne vix superantibus. Corolla ad fauces albo-barbata calyce intus glanduloso 3-plo longior, lobis tubo 3-plo longioribus. Filamenta antheris dimidio breviora.

Folia majora 8–10^{cm} longa 3.5–4^{cm} lata, minora 2.5–4.5^{cm} longa, 1.5–2.5^{cm} lata, nervis lateralibus utrinsecus 5–7, venis transversis subtus conspicuis, petiolis 3–5^{mm} longis. Pedunculi 0.5–3^{cm} longi. Thyrsus 3–4^{cm} longus atque latus, ramis secundariis aut primariis apice cymiferis, bracteolis lineari-lanceolatis 1–2.5^{mm} longis, floribus 3.5–4^{mm} longis. Calycis pubescentis segmenta ovata acuta intus circiter 6-glandulosa. Corollae segmenta utrinsecus puberula oblonga obtusa. Filamenta breviter filiformia, antheris oblongis 2^{mm} longis breviter acutata. Disci squamae sejunctae semiorbiculares. Ovarii carpella ovoidea hirtella. Folliculi non visi.

Embaulada, Depart. Zacatepéquez, Guat., alt. 1800^{m}, m. Dec. 1889, *Heyde et Lux*, n. 4534 Pl. Guat. etc., qu. ed. Donn. Sm.—Naranjo, Depart. Santa Rosa, Guat., alt. 1100^{m}, Maj. 1893, *Heyde et Lux*, n. 4533 Pl. Guat. etc., qu. ed. Donn. Sm.

Lithospermum Guatemalense Donn. Sm.—Suffruticosum canescens scabro-strigosum, caulibus pluribus strictis foliosis superne 2–3-chotomis. Folia sessilia suberecta lineari-lanceolata acuta basi obtusa subtriplinervia subtus densius strigosa, floralia conformia reducta. Flores brevissime pedicellati. Corolla cylindracea segmentis calycinis linearibus 3-plo longior, faucibus nudis, lobis rotundatis. Antherae subsessiles.

Caules 3–4.5^{dm} longi. Folia approximata 3–5^{cm} longa 5–8^{mm} lata, nervo laterali utrinsecus 1 opposito e basi remoto. Racemus floriferus pauciflorus vix scorpioideus, fructiferus elongatus. Calyx floriferus quam bractea paulo brevior, fructiferus 2–3-plo brevior, segmentis 7^{mm} longis dense longeque strigosis. Corolla aurata (cl. Seler in schedulis) 21^{mm} longa e basi sensim ampliata extus pubescens, lobis 3^{mm} longis atque latis. Antherae paulo infra fauces insertae oblongae 2^{mm} longae obtusae. Stylus paulo exsertus, stigmatibus distinctis. Nuculae plerumque binae ovoideæ 3.5^{mm} longae ecarinatae albae nitidae foveolatae areola basilari gynobasi planae affixae.

Trinidad, Depart. Huehuetenango, Guat., alt. 1800^{m}, Aug. 1896, *Seler*, n. 3082.

Cyphomandra heterophylla Donn. Sm.—Glabra. Folia nitida penninervia dimorpha, inferiora ampla utrinsecus 4-pinnatilobata, superiora integra acuminata gemina disparia, alterum e basi inaequali subcordata oblongo-ovatum superne obliquum, alterum dimidio paene brevius cordiforme. Racemi pedunculati simplices aut e basi furcati scorpioidei elongati, floribus pedicellos aequantibus.

Frutex biorgyalis, trunco crasso, ramis fistulosis. Folia coriacea, inferiora (ad ramos primarios tantum obvia) subtus pallidiora basi cordata circumscriptione oblongo-ovata 3.2–4^{dm} longa 3–3.5^{dm} lata usqua ad $\frac{2}{3}$–$\frac{4}{5}$ lobata, lobis 3 lateralibus cum terminali late oblongis 6–7^{cm} latis breviter acuminatis, lobo quarto infimo brevi ovato deflexo, sinubus rotundis crispatis, petiolis 12–15^{cm} longis. Folia superiora concoloria 5-6 penninervia, in eodemjugo majus 14–20^{cm} longum, 7–11^{cm} latum, petiolo 2.5–3^{cm} longo, folium minus 7.5–11^{cm} longum 6–8.5^{cm} latum, petiolo 1.5–2^{cm} longo. Racemi circinnati secundiflori pedunculo 4–6^{cm} longo adjecto usque ad 12–18^{cm} longi, fructiferi usque ad 3^{dm} longi. Calyx 5^{mm} altus, lobis rotundis apiculo barbato instructis. Corolla purpurascens 20–22^{mm} longa, tubo 3^{mm} alto, lobis lineari-lanceolatis obtusis ad apicem versus intus pubescentibus. Stamina duas corollae partes aequantia, filamentis complanatis deorsum dilatatis brevissime coalitis 2^{mm} longis, antheris linearibus rectis, connectivo postice incrassato sub antherae apice evanido infra loculos gibboso-producto. Ovarium conicum 7^{mm} altum in stylum gracilem aequilongum desinens, stigmate capitato. Bacca prasina ovalis 3^{cm} longa.—Ad *C. Tejore* Sendt. foliis inferioribus ad *C. Hartwegi* Sendt. foliis superioribus floribusque accedit, ab utraque glabritate recedit.

La Emilia, Llanuras de S. Clara, Cost., alt. 250^{m}, Apr. 1896, *Donn. Sm.*, n. 6670 Pl. Guat., etc., qu. ed. Donn. Sm.—Buenos Aires, Cost., alt. 300^{m}, Jan. 1892, *Tonduz*, n. 6603 herb. nat. Cost.—Turrialba, Cost., alt. 500^{m}, Sept. 1894, *Pittier*, n. 9059 herb. nat. Cost.—Santa Clara, Cost., Sept. 1896, *Cooper*, n. 10,215 herb. nat. Cost.—Waldeck prope Madre de Dios, Cost., Oct. 1896, *Pittier*, n. 10,294 herb. nat. Cost.—Tuis, Prov. Cartago, Cost., alt. 650^{m}, Nov. 1897, *Tonduz*, n. 11,496 herb. nat. Cost.

Dermatocalyx parviflorus Oerst.—Haec species heterogoneo-dimorpha, e solis floribus brevibus 6^{mm} longis, antheris subsessilibus, stylo elongato descripta, formam insigniter diversam praebet inflorescentia arcte compacta, floribus 2.8^{cm} longis caducissimis, filamentis 1^{cm} longis, stylo quam ovarium breviore.—Suffrutex epiphyticus, foliis nonnunquam alternis. Ab incolis *Colmillo* (molaris) vocatur.

Suerre, Llanuras de Santa Clara, Cost., alt. 300^{m}, Apr. 1896, *Donn. Sm.*, n. 6706 Pl. Guat., etc., qu. ed. Donn. Sm., forma longiflora.—La Palma, Cost., alt. 1550^{m}, Aug. 1898, *Tonduz*, n. 7450 Pl. Guat., etc., qu. ed. Donn. Sm. (n. 12,427 herb. nat. Cost.), forma breviflora.

Alloplectus calochlamys Donn. Sm.—Folia supra velutina subtus cano-sericea magnitudine leviter disparia oblongo-lanceolata utrinque acute angustata. Pedunculi 1–3-ni. Calyx usque ad quatuor partes partitus, tubo campanulato pentagono, segmentis utrinque sanguineis patulis parum inaequalibus integris replicativis basi mutue applicatis. Corolla succosa cylindrica calycem aequans recta basi parum gibbosa intus immaculata, lobis sanguineis minutis denticulatis. Antherae suborbiculares.

Suffrutex epiphyticus, caule rufescente. Folia in eodem jugo conformia, alterum 16–20^{cm} longa 5–6^{cm} lata altero quinta parte majus, petiolis canaliculatis marginatis 1.5–2^{cm} longis. Pedunculi sericei 1.5–3.5^{cm} longi superne incrassati. Bracteæ herbaceæ lineares 1.5^{cm} longae. Calyx subobliquus 2.5^{cm} longus, tubo argyrosericeo 5^{mm} alto, segmentis oblongo-ovatis villosis. Corolla villosa ad fauces haud contracta, lobis rotundatis 1.5^{mm} longis. Vagina staminifera tota paene adnata 8^{mm} alta, filamentis tortis 1^{cm} longis, staminodio 3^{mm} longo, antheris in quadram conniventibus, loculis distinctis ovalibus 2^{mm} longis. Disci glandula unica lata. Ovarium ovoideum 4^{mm} altum villosum, stylo 1.5^{cm} longo superne incrassato, stigmate obliquo bilobo. Fructus ignotus.—*A. tigrino* Hanst. proximus tubo calycino insigniter differt.

Sacoyojú, Depart. Alta Verapaz, Guat., alt. 1200^{m}, Maj. 1879, *von Tuerckheim* (a Keck sub n. 456 distrib.).—Pansamalá, Depart. Alta Verapaz, Guat., alt. 1300^{m}, Jul. 1886, *von Tuerckheim*, n. 456 Pl. Guat., etc., qu. ed. Donn. Sm.

Aphelandra dolichantha Donn. Sm.—Folia nitida elliptica utrinque contracto-acuminata in petiolum brevem decurrentia. Spicae ternae subsessiles simplices, bracteis herbaceis integris ovato-lanceolatis calyce ter quaterve longioribus. Corollae albae tubus tenuissimus inter longissimos, labia brevia, antici lobis parum inaequalibus. Filamenta brevia, antheris inclusis.

Epiphytica, caule pubescente. Folia integra subtus pallidiora 13–18^{cm} longa 6.5–10^{cm} lata, nervis lateralibus utrinsecus 9–10 cum costa subtus conspicuis et pubescentibus, petiolis 5–10^{mm} longis. Spicae abbreviatae (in exemplaribus suppetentibus vix evolutis 9–11^{cm} longae), bracteis quadrifariis arcte imbricantibus 3–3.5^{cm} longis 1.2–1.3^{cm} latis praeter margines puberulos glabris plurinerviis. Calycis herbacei puberuli segmenta linearia 9–10^{mm} longa acuta. Corollae extus glandulari-puberulae in sicc. rufescentis tubus 5.5–6^{cm} longus 2^{mm} vix latus ad fauces breves paulo ampliatus ad $\frac{1}{5}$ longitudinis staminigerus, labium posticum oblongum 13^{mm} longum 5^{mm} latum breviter bilobum, labii antici lobum intermedium oblongo-ellipticum 18–20^{mm} longum 6–7^{mm} latum, lateralia oblongo-linearia 15–17^{mm} longa 4–5^{mm} lata. Filamenta 6^{mm} longa, antheris 3^{mm} longis apiculatis barba laterali connexis.

Discus cupularis 1.5^{mm} altus. Ovarium 2^{mm} longum, styli lobis 1^{mm} longis. Capsulae desunt.

Suerre, Llanuras de Santa Clara, Cost., alt. 300^{m}, Febr. 1896, *Donn. Sm.*, n. 6689 Pl. Guat. etc., qu. ed. Donn. Sm.

Glockeria monolopha Donn. Sm. — Folia subtus lineolata oblongo-ovata acuminata ima basi cuneata. Thyrsi pyramidati laxiflori. Corollae tubus tenuis in fauces late cylindraceas rectas apice haud contractas abrupte ampliatus, labium posticum lineari-oblongum, anticum sub angulo recto divergens minutissime acuteque dentatum.

Caulis herbaceus 4^{dm} altus tetragonus, angulis glandulari-pubescentibus. Folia untrinque sparsim pubescentia 12-16^{cm} longa 6.5–9^{cm} lata, petiolis 1.5–4^{cm} longis. Thyrsi plerumque gemini folia superantes pubescentes, bracteis 2 foliaceis petiolatis cordiformibus aut oblongo-ovatis 2.5–5^{cm} longis, bracteolis subulatis 2-3^{mm} longis. Calycis glandulis conspersi segmenta linearia 4–5^{mm} longa. Corolla tenuiter membranacea glabra in sicc. flavescens, tubo 3^{mm} longo 1.5^{mm} lato, faucibus 1.5^{cm} longis, labiis corollam unilobam quasi simulantibus, postico 4^{mm} longo integro, antici dentibus lateralibus 0.5^{mm} longis, intermedio 0.25^{mm} vix longo. Filamenta 3^{cm} longa, antheris 3^{mm} longis. Capsula tetrasperma 12^{mm} longa calyce aucto triente longior in tertiam partem aspermam contracta.

Circa Capetillo juxta vias, Depart. Zacatepéquez, Guat., alt. 1500^{m}, Nov. 1889, *Heyde* et *Lux*, n. 4556 Pl. Guat. etc., qu. ed. Donn. Sm.

Glockeria ventricosa Donn. Sm.— Folia longe petiolata ovata aut oblongo-ovata acuminata basi rotundata aut subcordata. Thyrsus contractus elongatus densiflorus, bracteolis oblongis acuminatis. Corolla supra ovarium antice constricta, tubo antice inflato, faucibus cylindraceis subincurvis apice haud constrictis, labio postico elliptico, antici patentis dentibus brevibus rotundatis.

Suffrutex, ut videtur, ramulis teretibus cano-pilosis. Folia utrinque pilis conspersa 13–17^{cm} longa 6.5–9.5^{cm} lata, petiolis 4–8^{cm} longis. Thyrsus 3.5–5^{dm} longus, bracteis 2 foliaceis petiolatis ovato-lanceolatis 3–4.5^{cm} longis, bracteolis 8–13^{mm} longis. Calyx glandulari-pubescens 7^{mm} longus, fructigerus usque ad 13^{mm} longus, segmentis linearibus. Corollae parce pilosae in sicc. coccineæ tubus subglobosus diam. 3–4 millemetralis, fauces 18^{mm} longae, labium posticum 8–10^{mm} longum 4–5^{mm} latum integrum, antici dentibus 1.5^{mm} longis.

Filamenta 3.5^{cm} longa, antheris 5^{mm} longis. Capsula tetrasperma $15–17^{mm}$ longa in tertiam partem aspermam contracta.— Speciei praecedenti affinis.

Alto del Roble, Volcan Barba, Cost., alt. 2609^{m}, Jan. 1891, *Pittier*, n. 3519 herb. nat. Cost.— Volcan de Turrialba, Cost., alt. 1800^{m}, Jan. 1899, *Pittier*, n. 7511 Pl. Guat. etc., qu. ed. Donn. Sm. (n. 13,223 herb. nat. Cost.).

Razisea spicata Oerst.—Species e speciminibus a solo Oersted adhuc lectis propter inflorescentiam non satis evolutam imperfecte descripta. Racemus longe pedunculatus elongatus, pedicellis primo singulis et brevissimis, aetate provectiore plurifasciculatis et internodia aequantibus. Antherae 1-loculares. Ovarium disco subgloboso paulo longius, ovulis in utroque loculo 2, stigmate globoso integro. Capsula lineari-oblonga in dimidiam aspermam contracta, seminibis 4 tuberculatis.

Suffrutex, ut videtur. Folia oblongo-elliptica aut -obovata acuminata in petiolum $1–3^{cm}$ longum attenuata interdum usque ad 32^{cm} longa et 11^{cm} lata obscure crenata. Pedunculi $4–10^{cm}$ longi, bracteis bracteolisque lineari-lanceolatis $3–4^{mm}$ longis, pedicellis interdum 7-fasciculatis et usque ad 8^{mm} longis. Calycis tubus 1^{mm} longus, segmenta linearia 7^{mm} longa. Corolla $5–6^{cm}$ longa, tubo 1^{cm} longo in fauces sensim ampliato, labio postico 1^{cm} longo, labii antici lobis ovatis 2^{mm} longis. Antherae oblongo-ellipticae 4^{mm} longae. Discus fere 2^{mm} longus atque latus. Ovarium 2.5^{mm} longum, stylo 7^{m} longo stamina paulo superante. Capsula 2^{cm} longa, dimidia superiore torosa, inferiore compressa, seminibus compressis, retinaculis 2.5^{mm} longis rectis acutis.

In sylvis prope Siquirres, Llanuras de Santa Clara, Cost., alt. 200^{m}, Nov. 1890, *Pittier*, n. 3168 herb. nat. Cost.— Shirores, Talamanca, Cost., alt. 100^{m}. Febr. 1895, *Tonduz*, n. 9299 herb. nat. Cost.— In dumetis fundi *Tuis* vocati, Prov. Cartago, Cost., alt. 650^{m}, Nov. 1897, *Tonduz*, n. 11503 herb. nat. Cost. — In summo monte juxta La Palma, Cost., alt. 1550^{m}, Aug. 1898, *Tonduz*, n. 7436 Pl. Guat. etc., qu. ed. Donn. Sm. (n. 12,494 herb. nat. Cost.).

Campderia paniculata Donn. Sm.— Folia cordiformia atque lata atque longa, apice bilobo. Racemi compositi in paniculam terminalem dispositi, pedicellis plurifasciculatis minute bracteolatis filiformibus. Perianthium alis in pedicellum decurrens, fructiferum parvum obovoideum.

Arbuscula (Thieme in schedula), ramulis cinereo-pubescentibus sulcatis flexuosis. Folia supra puberulo-asperula subtus fusco-pubescentia diametro

12–16 centimetralia, lobis subdeltoideis 1–3^{cm} longis obtusis sub angulo semirecto divergentibus, petiolis 1.5–3^{cm} longis, ocreis ovalibus 4^{mm} longis crassis caducis. Panicula sessilis folia aequans late pyramidata floribunda, bractea amplectente orbiculari 1.5–3.5^{cm} longa usque ad mediam bifida, bracteolis vix 1^{mm} longis, pedicellis 4–7-nis 3–4^{mm} longis triquetris medio articulatis. Perianthii coccinei 2^{mm} longi segmenta paene sejuncta ovalia, exteriora 3 late alata, interiora 2 plana. Filamenta brevissime monadelpha sensim dilatata ciliolulata 2^{mm} longa, antherarum loculis subglobosis discretis. Styli deflexi 0.5^{mm} longi. Perianthium fructiferum 5^{mm} longum pedicello longius, alis 1^{mm} latis, nuce triquetra ovoidea 3^{mm} longa nitida, semine conformi esulcato atro. Ab omnibus congeneribus tam foliis quam inflorescentia insigniter differt.

Ad ripas fluminis Chamelecon, Depart. Santa Bárbara, Honduras, alt. 500^{m}, Dec. 1888, *C. Thieme*, n. 5604 Pl. Guat. etc., qu. ed. Donn. Sm.

Euphorbia Chaculana Donn. Sm. (§TITHYMALOPSIS Kl. et Garcke.)—Sparsim pubescens. Radix tuberosa fusiformis, caulibus 3-chotomis, ramis repetitus dichotomis. Folia brevissime petiolata lineari-oblonga utrinque obtusa, chotomialia interdum ternata, majora oblongo-ovata. Involucra e dichotomiis graciliter pedunculata campanulata glabra, appendicibus coloratis ovalibus. Semina ovalia subquadrangula rugosa glabra.

Herba 8–17^{cm}, alta, radice 2^{cm} longa, diam. 1 centimetrali, caulibus stricte longeque ramosis, glandulis stipularibus nullis. Folia 1–1.5^{cm} longa 3–5^{mm} lata cartilagineo-marginata praeter costam subtus tantum manifestam enervia, facie superiori minute lepidota, utraque sparsim et margine densius pubescentibus, petiolis 1^{mm} longis. Pedunculi 7–12^{mm} longi folia fulcientia plerumque aequantes. Involucrum 1^{mm} altum atque latum, lobis minutis fimbriatis, glandulis 5 transverse ellipticis, appendicibus glandula vix latioribus involucro aequilongis integris aut erosis. Capsula glabra 3^{mm} alta, seminibus 2^{mm} longis. Styli deficiunt.—Ad *E. biformem* S. Wats. et *E. Plumerae* S. Wats. proxime accedens, ab ea foliis subsesilibus, ab hac seminum sculptura, ab utraque pedunculis longioribus recedit.

Chaculá, Depart. Huehuetenango, Guat., alt. 1600^{m}, Jan. 1896, *Seler*, n. 3128.

Euphorbia Seleri Donn. Sm. (§CHAMAESYCEÆ Boiss.)—Canescens. Rhizoma lignosum, caulibus procumbentibus dichotomis, setulis stipularibus geminis. Folia breviter petiolata e basi semicordata ovata obtusa integerrima glabrescentia. Involucra ad nodos supremos in axilla una solitaria breviter pedunculata campanulata subglabra, lobis triangulari-subulatis, glandulis transverse ovalibus flavescentibus, appendicibus obovatis integris. Styli longiusculi. Semina ovata subtrigona rugulosa.

Rhizoma 1^{dm} longum ramosum. Caules pubescentes $10–15^{cm}$ longi, stipulis 1^{mm} longis. Folia disticha opposita $5–7^{mm}$ longa $4–5^{mm}$ lata carnulosa exceptis novellis fere glabra, inferiora minora, petiolis quam stipulae paulo longioribus. Pedunculi $1–2^{mm}$ longi. Involucra 1.5^{mm} longa 1^{mm} lata a foliis fulcientibus 2–3-plo superata, lobis ciliatulis, glandulis 4, appendicibus albis 1.5^{mm} longis ad apicem versus 1^{mm} latis basi glandula aequilatis. Styli 1^{mm} longi basi coaliti ultra medium bifidi. Capsulae (immaturae tantum suppetentes) paene glabrae, coccis subcarinatis, seminibus erubescentibus.

Chaculá, Depart. Huehuetenango, Guat., alt. 1600^{m}, Jan. 1896, *Seler*, n. 3127.

CECROPIA MEXICANA Hemsl., var. **macrostachya** Donn. Sm.—Spicae femininae quaternae usque ad 4^{dm} longae, pedunculis partialibus 8^{mm} longis glabris estriatis, seminibus brevius ovalibus.

Laguna de Buenos Aires, Cost., alt. 300^{m}, Febr. 1892, *Pittier*, n. 6666 herb. nat. Cost.—Atirro, Prov. Cartago, Cost., Mart. 1894, *Donn. Sm.*, n. 4934 Pl. Guat. etc. qu. ed. Donn. Sm.—Rio Poas, Cost., alt. 1200^{m}, Mart. 1896, *Donn. Sm.*, n. 6771 Pl. Guat. etc., qu. ed. Donn. Sm.—La Concepcion, Llanuras de Santa Clara, Cost., alt. 200^{m}, Febr. 1896, *Donn. Sm.*, n. 6774 Pl. Guat. etc., qu. ed. Donn. Sm.

Cecropia polyphlebia Donn. Sm.—Folia supra strigoso-scabrida subtus niveo-arachnoidea 10–11-fida, segmentis obovato-oblongis breviter acuminatis, nervis lateralibus arcte approximatis juxta marginem arcuato-anastomosantibus sicut costae venaeque subtus fuscis, petiolis glabris costas majores aequantibus. Spicae femininae sessiles quaternae breves crassae pedunculo brevissimo 3-plo longiores. Semina oblonga.

Stipulae longe denseque cinereo-sericeæ $9–11^{cm}$ longae. Folia coriacea pilis e tuberculo ortis aspera peltata suborbicularia 4^{dm} in diametro superne usque ad 5 partes inferne usque ad 7 partes fissa, segmentis plerumque 10, majoribus infra apicem $7–8.5^{cm}$ latis, minoribus $3.5–5^{cm}$ latis, costis subtus validis et cinereo-pubescentibus, majoribus $20–24^{cm}$ longis, minoribus $12–14^{cm}$ longis, nervis lateralibus utrinsecus 20–30, venis subparallele transversis crebris. Pedunculus communis femininus $1.5–2^{cm}$ longus, spicis $4.5–5.5^{cm}$

longis 1^{cm} in diam. seminibus 2.2^{mm} longis, compressione 3–4-gonis scrobulatis flavescentibus. Spathae utriusque sexus et spicae masculinae desunt.—*C. tubulosae* Ruiz proxima, ut videtur. *C. Humboldtiana* Klotzsch ob inflorescentiam fem. (descriptione adhuc carentem) nostrae speciei affinis, foliis tamen discrepans, pedunculum fem. $3.5–4^{cm}$ longum praebet, spicas habet 2–9-nas plerumque quinas sessiles $5.5–7^{cm}$ longas 7^{mm} in diam., semina elliptica compressa scrobiculata flavescentia.

In sylvis prope LaPalma, Cost., alt. 1460^{m}, Sept. 1898, *Tonduz*, n. 7411 Pl. Guat. etc., qu. ed. Donn. Sm. (n. 12,642 herb. nat. Cost.).

Baltimore, Md.

NEW SPECIES OF WESTERN PLANTS.

T. S. BRANDEGEE.

Delphinium Purpusi, n. sp.— Perennial, slightly pubescent: stems somewhat leafy, 4–6^{dm} high from a fibrous root: leaves 10^{cm} or less in diameter, 3-cleft into incised or lobed mucronulate divisions on petioles 5–15^{cm} long: raceme 5–15^{cm} long, the few purplish red flowers on pedicels 1–2^{cm} long: spur thick and blunt, slightly curved, 15^{mm} long; lateral petals 8–9^{mm} long, the narrow laminæ yellow-bearded within; upper petals pale or white: sepals longer than the petals: follicles three, glabrous, reticulate-veined, 2^{cm} long: seeds 1^{mm} long, with a very loose cellular coating.

Erskine creek, southeastern California, *Dr. C. A. Purpus*, no. 5015.

This species closely resembles *D. nudicaule* T. & G. in its leaves, but has flowers of a quite different color, that dry to lavender rather than scarlet. The lateral petals are broader, bearded, and not so sharply laciniate; the upper petals are differently shaped, entire, broader, and shorter. *D. nudicaule* belongs to the northern part of California.

Cleomella gracilis, n. sp.— A glabrous strict annual: stems 3^{dm} high, simple or sometimes with two short erect branches from near the base: the lowest leaves trifoliate; the others simple with flowering leafy branches 5^{mm} long in their axils or the uppermost with single flowers; stipules simple or divided into filiform deciduous bristles: leaflets 1–2^{cm} long, 1–1.5^{mm} wide, linear-spatulate, apiculate, on petioles 5^{mm} long or less, often sessile: flowers yellow, with petals 2^{mm} long equalling the stamens: capsule deltoid, 5^{mm} wide, 4^{mm} high on a curved pedicel 8^{mm} long: stipe 1^{mm} long: seeds seven, blotched with purple, not tapering to the base, marked somewhat like those of *C. plocasperma* Wats.

Twin Springs, Nevada, *Dr. C. A. Purpus*, no. 6342.

This may be an extreme form of *C. parviflora* Eng., but its strict habit gives it a very different appearance.

Glossopetalon pungens, n. sp.—Fruticose, cespitose, branching: stems 8–9^{cm} high: leaves crowded, 7–8^{mm} long, slightly short-hirsute, the margins, midrib, and 3–6 veins strongly thickened, alternate, narrowly oblong-elliptical, attenuate to each end and tipped with a spine 1^{mm} long: flowers terminating the stems or short branchlets on pedicels 3–4^{mm} long that bear three or four scarious bracts similar to the leaves but smaller: calyx of five broadly ovate bracts, 4^{mm} long, with denticulate margins, two or three of them spinose tipped, and the others acuminate: petals five, obovate-lanceolate, narrowed to the base, 7–8^{mm} long, 2^{mm} wide: the five stamens inserted with the petals as long as the calyx, the five opposite the calyx a third longer and with wider filaments: carpels two or three, pubescent, ovate, attenuate to the stigma, sessile upon the disk: ovules in each carpel two, collateral and ascending, inserted on the ventral suture above the base of the cell: fruit a firm coriaceous follicle equalling the calyx, opening along the ventral suture, usually one-seeded.

Sheep mountains, Nevada, growing on rocks at 4000–5000 feet elevation, *Dr. C. A. Purpus*, no. 6131.

This is a most interesting species, and may throw some light upon the true position of the genus in classification. It is so distinct from the other species that the generic characters have been somewhat included in its description so as to exhibit more certainly its affinity. The original species *G. spinescens* was collected by Mr. Wright near Frontera, New Mexico, and since then has been often found between western Colorado and eastern California. Dr. Gray, in the original diagnosis, thought the genus intermediate between Celastraceæ and Staphyleaceæ, and later with the description of an additional closely related species, *G. Nevadense*, refers it confidently to Staphyleaceæ, and adds: "as in the original specimens of *G. spinescens*, so in these, although seeds seem to be full-grown and well formed, I do not find a single developed embryo. If this should be straight and the albumen wanting, I should refer the genus to Rosaceæ near to Purshia; but I expect it will turn out otherwise." This newly discovered species was collected in abundance, with plenty of full grown and well-formed seeds exactly like those of the other two species, but unfortunately it resembles them also in having no embryos. Among the recent collections of *G. Nevadense*, however, some mature seeds containing embryos have been found, and from them it is seen that it is slender, cylindrical, curved into a half circle, 3^{mm} in length, incumbent, the radicle about as long and nearly as broad as the cotyledons, inferior; testa brown, coriaceous; albumen fleshy, rather copious. *G. pungens* usually has two follicles, sometimes three or by abortion one. Here it is interesting to note that the other species do not have their solitary follicles inserted on the center of the disk. The stigma is somewhat lateral, and in *G. pungens* more decidedly so. The generic description of Glossopetalon will have to be slightly amended so as to include this plant, but the additional characters derived from the new form and from mature seed seem only to strengthen its anomalous position.

A fourth species *G. meionandrum* Koehne,[1] collected in the Gunnison region, Colorado, by Dr. Purpus, has been added to the genus.

Horkelia (Ivesia) **mutabilis,** n. sp.—Stems several, 3^{dm} high, erect, branched above, villous, leafy: stipules ovate-lanceolate, acute, 5–7^{mm} long; basal leaves numerous, 12–20^{cm} long, silky-hirsute, pinnate, leaflets fifty or less, sessile, more or less imbricated, 2–5^{mm} long, usually divided to the base into obovate-oblong pointed segments: cyme much branched, many-flowered, open: disk 4^{mm} in diameter: bractlets triangular-lanceolate, half as long as the broadly triangular-lanceolate sepals: petals yellow, exceeding the bractlet but not as long as the sepals, narrowly lanceolate-obovate, acute: stamens five; filaments filiform, 2^{mm} long: styles two to seven; akenes few and usually mottled.

Table and Charleston mountains, Nevada, and Pine valley mountains, Utah, *Dr. C. A. Purpus*, nos. 6195, 6079, 6381.

The anthers in some of the specimens are purple.

PURPUSIA, n. gen.—Calyx tube elongated, tubular, widening above; lobes five, valvate; bractlets none: petals five: stamens five, opposite the sepals; filaments filiform; anthers didymous: disk lining the calyx tube and thickened at the base: carpels six or seven on a stipitate receptacle; styles nearly terminal, filiform, articulate at base; embryo somewhat curved; cotyledons broadly oblong, about four times the length of the small inflexed superior radicle: akenes attached laterally slightly above their base: leaves alternate, imparipinnate; stipules adnate to base of petiole: stems erect: inflorescence corymbosely racemose.

[1] Gartenflora 43: 237.

This genus is related to Potentilla and Chamærhodos. From Potentilla it differs in having a long calyx tube and no bractlets, and from Chamærodos in its terminal style and the position of the stamens, and it is distinct from both in its peculiar stipitate receptacle.

Purpusia saxosa, n. sp.—Perennial from a stout root, 10–15^{cm} high, hirsute and somewhat viscid: basal leaves numerous, pinnate; leaflets two or three pairs, the lowest pair on pedicels 5^{mm} long, irregularly oblong or orbicular, 10–15^{mm} in diameter, more or less deeply cut into five to ten rounded entire or incised lobes; stem leaves similar, becoming simple and bract-like above, their stipules 7^{mm} long, ovate-acuminate, entire or incised: stem branched above, bearing solitary flowers in the axils of the leaves, forming a leafy paniculate cyme: flowers on pedicels 1–2^{cm} long, exceeding the bracts: calyx tube 3^{mm} long, indistinctly ten-ribbed; lobes 4^{mm} long, lanceolate-acuminate: petals white, 4^{mm} long, 1^{mm} wide, slightly acuminate, inserted, opposite the sinuses: anthers 1^{mm} long, equaling the filaments: receptacle hirsute, no broader than the gynophore, which is 2^{mm} long, pubescent and narrowly cylindrical: styles 2^{mm} long: akenes smooth.

Sheep mountains, Nevada, at 4000–5000 feet altitude, *Dr. C. A. Purpus*, no. 6134.

CHAMÆBATIA FOLIOLOSA Benth. var. **australis,** n. var.—Much less glandular-pubescent than the type: leaves narrower in outline, three times as long as wide and barely more than twice pinnate: calyx lobes shorter: ovary smooth.

La Grulla, Lower California, *C. R. Orcutt* in 1886; Mt. San Miguel near San Diego, *D. Cleveland;* and reported by Mr. Orcutt from Point Loma near the ocean.

Typical *C. foliolosa* is more northern in its range and grows at considerable altitudes in the Sierra Nevada, so that it is somewhat surprising to find a form so far south and near the sea level.

Boykinia Purpusi, n. sp.—Slender and smooth except the upper part of the glandular stem, 20–25^{cm} high: leaves round-reniform, the largest 4^{cm} wide, with five to seven acutely incised lobes; petioles 6–7^{cm} long or less, with ramentaceous bristles at their dilated bases: the paniculate cyme 8–10^{cm} long, secund: petals white, 3^{mm} long, twice the length of the lanceolate-triangular sepals: stamens five, or sometimes perhaps abnormally seven, with filaments 0.5^{mm} long.

On moist rocks in Black cañon of the Uncompahgre river, Colorado, at an elevation of 7200 ft., *Dr. C. A. Purpus*, no. 512.

The specimens are young and have no mature fruit.

Mentzelia leucophylla, n. sp.— Biennial or triennial (?): stems several from the root, 3–4^{dm} high, covered with a soft white pubescence: radical leaves 6–8^{cm} long and 1^{cm} wide, linear-oblong, attenuate to the base and apex, regularly sinuate-dentate, densely covered on both surfaces with short rigid hairs, upwardly barbed, those of the margin minutely glochidiate; stem leaves oblong, 4^{cm} long, 1–1.5^{cm} wide, rounded at the top and pointed, cordate-clasping at base especially the upper ones, slightly sinuate-dentate, densely hispid, only the marginal hairs glochidiate: flowers bright yellow, on pedicels 1–8^{mm} long, in a sparingly divaricately branched panicle: petals broadly spatulate, slightly retuse and pubescent at tip, 1^{cm} long: sepals triangular acuminate, obtuse, 6^{mm} long: outer stamens broadly petaloid, the blades slightly dentate above: capsule 8–10^{mm} long and nearly as broad: seeds flat, margined by a border less than 0.5^{mm} wide.

Ash Meadows, Nevada, *Dr. C. A. Purpus*, no. 6032.

Aplopappus (STENOTUS) **MacLeanii,** n. sp.—Cespitose from a multicipital caudex, the woody stems 6–12^{cm} long, sending down rootlets: leaves 2^{cm} long and less than 1^{mm} wide, crowded on branchlets 2–3^{cm} long, linear-lanceolate with stout midrib and ciliate with short stiff hairs: peduncles 2^{cm} long, terminating the branchlets, bearing two bracts similar to the leaves and a single head about 8^{mm} high and wide: involucral bracts linear-lanceolate, minutely glandular-ciliate: rays six to eight, shortly lobed at tip, 2^{cm} long: disk flowers twenty to twenty-five; styles dark margined, with long conical tips: pappus soft and white, of numerous bristles nearly as long as the corolla: akenes short, hirsute.

Near Dawson, Northwest Territory, *John MacLean*, in 1898.

This plant is nearest *A. stenophyllus* Gray, but is easily distinguished from it by the more condensed habit and the short acute ciliate leaves.

Eriophyllum aureum, n. sp.—Annual, whitened with close cottony wool, much branched from the base, the usually simple, monocephalous stems 4^{cm} high, leafy: cauline leaves $5–8^{mm}$ long, alternate, oblong-spatulate, obtuse, narrowed at the base; radical ones broader and sometimes slightly lobed: heads barely exceeding the leaves, 6^{mm} high, forty to fifty-flowered: involucre of about ten narrowly ovate acuminate separate scales: flowers golden yellow; the rays oblong, with a truncate retuse very slightly five or six-lobed tip; disk flowers equalling the involucre, funnel-form, bullate-rugose; style tips conical; appendages of the anthers narrowly linear or subulate: pappus a crown of about six very minute denticulate scales of different widths: akenes linear-clavate, nearly smooth: receptacle convex, the height about twice the width, smooth.

Lone Pine, California, *T. S. Brandegee*, April 16, 1891.

The numerous golden-yellow flowers contrasting with the very white cottony stems and leaves, and the habit of forming hemispherical tufts make this a very showy species.

Eriophyllum Congdoni, n. sp.—Annual, $1–2^{cm}$ high, whitened with loose cottony wool: stems branched from about the middle, monocephalous: lower leaves few, spatulate, sometimes two or three-toothed above, attenuate into a petiole; upper leaves mostly entire, sessile, lanceolate-spatulate: heads $7–10^{mm}$ high, forty to fifty-flowered, on peduncles $4–5^{cm}$ long: involucre of eight or nine oblong-acuminate distinct scales, thickened at the center and base: rays yellow, about eight, broadly elliptical, entire or slightly retuse at tip: disk corollas equalling the involucres, funnel-form with a rather long cylindrical tube, nearly glabrous: style tips almost truncate: anther appendages broadly ovate: akenes 3^{mm} long, linear-clavate, hirsute; pappus of the disk akenes $1.5-2^{mm}$ long, the longer scales narrow, the shorter ones wider and more laciniate; pappus of the ray akenes shorter and similar: receptacle convex, higher than wide, smooth.

"Mountains near Hennessy's, Mariposa county," California, May 1894.

Received from Mr. J. W. Congdon under the name of *E. nubigenum* Greene.

Eriophyllum paleaceum, n. sp.—Annual, whitened with loose cottony wool, $10-12^{cm}$ high, with many monocephalous branches: leaves $1-1.5^{cm}$ long, linear-spatulate, the lower somewhat attenuate into a petiole and often two or three-lobed or dentate about the tip: involucre of eight narrow acuminate scales, distinct to the base: heads $6-8^{mm}$ high, forty to fifty-flowered, on peduncles $2-3^{cm}$ long: rays six or seven, yellow, narrowly elliptical, 7^{mm} long, very slightly two or three-lobed at tips: disk flowers 3^{mm} long, equaling the involucre, funnel-form with a short cylindrical pubescent tube: style tips short-conical; appendages to the anthers narrowly ovate: akenes 2.5^{mm} long, linear-clavate, rounded at the top, hirsute; pappus a crown of minute denticulate scales: receptacle conical, twice as high as broad, paleceous especially about the apex where half a dozen persistent linear scales become 1^{mm} long.

Kernville, California, May 14, 1892, and Olancha, California, May 1891, *T. S. Brandegee*; also in the mountains of Tulare county, California, *Dr. C. A. Purpus.*

Laphamia intricata, n. sp.—Puberulent and slightly pubescent above; intricately much branched from a woody root, $15-20^{cm}$ high, the numerous stems each bearing two to six heads on peduncles $0.5-2^{cm}$ long: leaves nearly all alternate, linear, $5-8^{mm}$ long, obtuse, dilated above to 1^{mm} wide, somewhat hispid: bracts of the involucre 3^{mm} long, linear, with thin margins especially the inner ones, the acute tips more pubescent, midrib thickened: ray flowers none; disk flowers about thirty, bright yellow, with glandular pubescent tube: pappus wanting: akenes hirsute and slightly ciliate.

Pahrump and on Sheep mountain, Nevada, on rocks, *Dr. C. A. Purpus*, nos. 6051 and 6134.

Laphamia fastigiata, n. sp.—Scabrous puberulent, cespitose from a woody root: stems 10-14^{cm} high, the short branches monocephalous: lower leaves opposite, spatulate, attenuate into a margined petiole, entire to trifid, 2–3^{cm} long; stem leaves smaller, with short petioles, 3–4^{mm} wide, cuneate at base and trifid above, the central lobe much the longest: involucre of about fifteen linear acute slightly hispid-pubescent bracts that are carinate thickened at the base: rays none: disk flowers about forty, light yellow, 5^{mm} long, equaling the involucre; tube pubescent: pappus a single delicate awn, half the length of the corolla or less, sometimes wanting: akenes slightly ciliate on the margins.

Sheep mountain, Nevada, *Dr. C. A. Purpus*, no. 6142.

Gilia sedifolia, n. sp.—Glandular-pubescent except the lower leaves: stem simple, thick and fleshy from a stout biennial root: leaves crowded near the base, fleshy, linear-spatulate, obtuse, sessile, entire, 1^{cm} long, the upper ones becoming smaller and bract-like: peduncles 12^{mm} long or less, rarely two-flowered, solitary from the axils of the lower leaves or crowded in those of the bracts from the middle of the stem upwards: calyx 4^{mm} long, its triangular-acuminate lobes equaling the violet corolla: tube of the corolla as long as its ovate not spreading lobes: stamens inserted in the sinuses, shorter than the corolla lobes: style 3^{mm} long: capsule as long as the calyx, about fifteen-seeded: seeds not developing spiricles when wetted, decidedly wing-margined.

Uncompahgre range, Colorado, at 12,000 ft. altitude, *Dr. C. A. Purpus*, no. 697.

An abundance of old leaves persists about the base of the stem, giving it the appearance of a perennial, although it can only be a biennial. Flowers are borne sparingly in the axils of the lower leaves, but are crowded throughout the upper half, completely hiding the small bracts. The thick fleshy leaves recall those of some sedums.

Phacelia Purpusi, n. sp.—Annual, 2–3^{dm} high, somewhat branching, hispid-hirsute and glandular-viscid above: leaves ovate, acuminate or obtuse, entire, 2–6^{cm} long including the petiole, the smaller ones tapering to a sessile base: racemes or spikes 5–10^{cm} long, secund, dense; pedicels 1–2^{mm} long: corolla violet, broadly open campanulate, slightly exceeding the spatulate-obovate unequal calyx lobes; appendages salient, long, united at base of the stamen; stamens sparingly bearded at base, exserted beyond the corolla lobes: style long exserted, cleft to below the middle: capsule hirsute, broadly ovate, pointed, half as long as the calyx lobes: ovules two to four to each placenta; seeds regular, turgid at maturity, not angled, dark brown, deeply favose, a little more than 1^{mm} long.

Sequoia Mills, California, *T. S. Brandegee*; also Middle Tule river, California, *Dr. C. A. Purpus*, no. 5603.

Young plants collected by J. W. Congdon at Sherlock, Mariposa county, California, June 15, 1898, probably belong to this species. It is apparently nearest *P. circinatiformis* Gray.

Allocarya salsa, n. sp.— Annual, rough-hispid throughout, prostrate-spreading 1–2^{dm} in diameter, with rather few stout, often inflated leafy branches simple or branched toward the ends: leaves broadly linear, pustulate-hispid, otherwise glabrous: bracts similar, longer than the calyxes of the dense spikes: flowers sessile: calyx clavate, the elongated lobes widely spreading: corolla 4^{mm} long, with spreading lobes and white inconspicuous processes: nutlets glabrous, 2^{mm} long, lanceolate, unsymmetrical, longitudinally rugose on the unequal inner faces, transversely rugose on the back; scar of attachment nearly basal, small on the three caducous nutlets, the fourth attached by a broad surface and probably separating only by decay,

Alkaline soil, Twin springs, Nevada, *Dr. C. A. Purpus*, no. 6339, August 1898.

In aspect unlike any other species known to me.

Cryptanthe excavata, n. sp.— Annual, 1–2^{dm} high, rather sparingly hirsute-hispid, branching from the base, branches slender, flexuous: fruiting spikes usually in threes and flowers at length remote: calyx 2–3$^{\mathrm{mm}}$ long, yellowish-setose, slightly elongating in fruit, not appressed to the rachis, strongly gibbous from the horizontal development of the solitary nutlet: corolla 4–5$^{\mathrm{mm}}$ long and the spreading lobes quite as broad, throat nearly closed by the prominent white processes: nutlets lanceolate, light brown, 2–5$^{\mathrm{mm}}$ long, rather sharply angled, recurved at the tip, minutely tessellate and with scattered papillæ; groove triangular, excavated, a little more than one third as long as the nutlet.

Stites, Colusa county, and also in adjacent Lake county, California, *T. S. Brandegee*, April 1892.

Cryptanthe costata, n. sp.—Annual, 0.5–2$^{\mathrm{dm}}$ high, erect, rigid, branching from the base, appressed-pubescent and pilose-hispid; the inflorescence hispid and bracteate throughout: leaves narrowly lanceolate, widest at base, 2–3$^{\mathrm{cm}}$ long: bracts nearly as long as the rather dense fruiting calyxes: flowers 2$^{\mathrm{mm}}$ long, scarcely spreading, constricted below the white processes: fruiting calyxes about 5$^{\mathrm{mm}}$ long, the slender costate segments erect persistent and not spreading: nutlets four, minutely and irregularly rugose, sharply thin-margined, the three smaller a little more than 1$^{\mathrm{mm}}$ long, the fourth larger and more persistent, the ventral face triangular-lanecolate, the groove of the same shape, open quite to the base.

Borregos springs, Colorado desert, *T. S. Brandegee*, April 18, 1895.

In appearance it is somewhat intermediate between *C. angustifolia* and *C. crassisepala*. At maturity it is of a shining straw color, and quite conspicuous on account of the glistening setæ of the large persistent calyxes.

CRYPTANTHE RAMOSISSIMA Greene. Dr. Rose, working with additional material collected by Dr. Palmer,[2] has corrected errors of the earlier descriptions, and noting the second nutlet often developed records his opinion that *K. ramosissima* and *K. maritima* are too nearly related. This opinion seems to be fully justified, for the only means of separating them seems to be by their habitat, the mainland forms passing usually as *Krynitzkia* or

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[2] Proc. U. S. Nat. Mus. **11**: 532.

Cryptanthe ramosissima, while the island plants are named *K.* or *C. maritima.* They vary much in habit, apparently being able to adapt themselves to very diverse conditions. All the forms that I possess have one peculiarity that separates them sharply from all other species of Cryptanthe, even from *C. Cedrosensis*, namely, they have only two ovules! The numerous specimens examined range in habitat from Inyo county, the Mohave and Colorado deserts, to northern Lower California and Lagoon head, and the many islands off the coast of Upper and Lower California from Santa Catalina to Santa Margarita.

Penstemon floridus, n. sp.—Glabrous and glandless, $3-4^{\mathrm{dm}}$ high: leaves thin-coriaceous, $5-7^{\mathrm{cm}}$ long, ovate-lanceolate, sessile, acutely spinulose dentate or the smaller oblong and short-petioled, none connate-perfoliate: thyrsus virgate, 3^{dm} long; peduncles and pedicels $1-2^{\mathrm{cm}}$ long or shorter: corolla rose-purple, $2-2.5^{\mathrm{cm}}$ long: sepals ovate-acuminate, 4^{mm} long; the tube of the corolla two to three times as long, then dilated into a ventricose throat and slightly contracted at the mouth, lobes somewhat spreading: sterile filament glabrous; anthers explanate: capsule three times as long as the sepals, broadly ovate: seeds black, irregular in form, obtusely angled, rugose and granular.

Mt. Magruder, Nevada, *Dr. C. A. Purpus*, no. 5928.

This plant is nearly related to *P. spectabilis*, a species given that name by Dr. Thurber, who collected it in southern California. Dr. Gray included with it plants from the Interior Basin, but the above described species seems to be quite distinct. Some of the differences between it and *P. spectabilis* are the absence of connate-perfoliate leaves, the more virgate thyrsus, the corollas with somewhat constricted mouth and short lobes not widely spreading. *P. spectabilis* is a common species of western San Diego county, California.

Pentstemon incertus, n. sp.—Suffrutescent, $3-4^{\mathrm{dm}}$ high, much branched from the base, glabrous excepting the slightly glandular peduncles and pedicels: leaves narrowly linear-lanceolate, $2-4^{\mathrm{cm}}$ long, 2^{mm} wide, the lowest shorter: sepals ovate, acuminate, 5^{mm} long: corolla distinctly bilabiate, violet (?) fading to lavender, 2.5^{cm} long, with a broad tube twice the length of the sepals, then dilated into a ventricose throat; lower lip deeply three-lobed and spreading, rarely sparingly yellow-bearded: sterile filament densely yellow-bearded above the middle.

Walker pass and sandy slopes of Argus mountains, California. *Dr. C. A. Purpus*, nos. 5351, 5346.

This species is near *P. fruticiformis* Coville, but is easily distinguished by its narrower leaves and differently shaped flowers; also its calyx lobes are not white-margined, and usually the corolla lobes are not bearded. The flower of *P. fruticiformis* has almost no proper tube, while that of *P. incertus* is two or three times the length of the sepals, and the throat is not so ventricose, nor the lobes so spreading. When dried the flowers of *P. incertus* become a dark lavender, while those of *P. fruticiformis* change to ochroleucous.

Pentstemon petiolatus, n. sp.—Glabrous, the calyx slightly pruinose: stems 10^{cm} high, cespitose from a woody root: leaves coriaceous, sharply serrate, broadly ovate, acuminate, $1–2^{cm}$ long and broad, cordate to cuneate at base, on petioles $10–15^{mm}$ long: the leafless thyrsus short, $2–4^{cm}$ long, 5 to 12-flowered; bracts ovate-acuminate, $1–3^{mm}$ long: sepals ovate, acuminate, 6^{mm} long: corolla 15^{mm} long, broadly funnelform, the short lobes spreading, the lower bearded within: sterile filament glabrous: capsule slightly exceeding the sepals, nearly as broad as long: seeds dark-colored, granular roughened and almost wing-angled.

Sheep mountain, Nevada, at 5000 ft. altitude, *Dr. C. A. Purpus*, no. 6136.

Dr. Purpus notes that the flowers were violet. Nearest to *P. deustus* Dougl., which has longer and narrower usually sessile leaves, and smaller flowers in a virgate leafy thyrsus.

Pentstemon (SACCANTHERA) **Purpusi,** n. sp.—Densely soft pubescent and somewhat glandular above: stems ascending from a woody base $6–15^{cm}$ high: leaves orbicular or broadly obovate, tapering to a short petiole or sessile, $8–10^{mm}$ wide, entire or rarely slightly crenate-dentate: thyrsus half the length of the stems; cymes short-pedunculate, one to three-flowered: corolla $3–3.5^{cm}$ long, violet, ventricose at the throat and not enlarged above, upper lip 5^{mm} long, lobed to the middle, lower lip the same length, three-lobed: sepals $7–8^{mm}$ long, ovate-acuminate or broadly linear: sterile filament glabrous; anthers short-ciliate along the line of dehiscence and bearing a few long woolly hairs near the filament: capsule longer than the sepals; seeds gray, irregularly cubical, sharply angled, 1–2^{mm} long, the surface slightly pitted.

Snow mountain, California, above 7000 ft. altitude, *Dr. C. A. Purpus*, July 1894, nos. 1157, 1259.

The dark purple stems, sepals, and bracts, with the bright violet flowers serve to make this one of the handsome species.

PENTSTEMON RŒZLI Regel var. **violaceus**, n. var.—Puberulent below and short pubescent above, not glandular and but slightly viscous about the calyx: stems numerous from a woody root, 15^{cm} high: thyrsus narrow and corolla little ampliate, dark violet: seeds irregular in shape, somewhat rugose, slightly pitted, smooth upon the larger face: capsule longer than the calyx.

Oriental, Gold mountain, Nevada, *Dr. C. A. Purpus*, no. 5995.

The purple stems and calyx and dark violet corollas give to the broad clumps of this species a pleasing effect.

Abronia alpina, n. sp.—Perennial (?), prostrate-spreading, forming mats about 20^{cm} in diameter, viscid-pubescent: leaves orbicular or slightly elongated, 3-5^{mm} in diameter, on petioles 10–15^{mm} long: involucres on peduncles 5–6^{mm} long, divided to the base into four or five narrowly ovate acuminate bracts 2–3^{mm} long, about five-flowered: perianth rose-colored to white, 12–15^{mm} long, salverform with narrow tube; the short lobes deeply obcordate, spreading to 8–9^{mm} wide: fruit 3-4^{mm} long, narrowed to both ends, thin coriaceous, obtusely or acutely five-angled, glabrous, tuberculate-veiny.

In Monatchy meadows of Mt. Whitney, at an elevation of 7000–8000 ft., and at Templeton near the craters, growing in loose granite sand, *Dr. C. A. Purpus*, nos. 1877, 1497.

An exceedingly handsome compact species, bearing so many flowers that the leaves are nearly hidden.

Eriogonum formosum, n. sp. (*E. giganteum* Wats. var. *formosum* K. Brandg.[3])—Sometimes but not commonly branching from the base: leaves densely white-tomentose on both sides, more or

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[3] Erythea **5**: 79.

less glabrate above in age, oblong-lanceolate or oblanceolate, 5–8$^{\mathrm{cm}}$ long, 1–2$^{\mathrm{cm}}$ wide, on stout petioles 2–4$^{\mathrm{cm}}$ long: cyme broad, ramose, foliaceous-bracted, on a peduncle 2$^{\mathrm{dm}}$ or more long, ultimate branchlets white-tomentose as well as hairy: involucres clavate, rather narrow, with short broad scarious-margined teeth, 4–5$^{\mathrm{mm}}$ long, tapering into a pedicel of about the same length, many-flowered: perianth rose-colored, about 4$^{\mathrm{mm}}$ long, segments somewhat appressed-hairy with prominent midrib, the outer ones obovate cucullate, the inner longer and tapering into a marginal claw: akene nearly as long as the flower, triquetrous above.

E. molle Greene may be maintained as a species by its habit, which is quite different from *E. giganteum*. It is not at all arborescent and bears its few-branched cymes on stout peduncles 6–10$^{\mathrm{dm}}$ long. In our garden it flowers nearly the whole year and bloomed, as probably all the perennial species do under favorable circumstances, the first year from seed. All the parts of the flower are about one half larger than those of *E. giganteum*, and the branches of the cyme are very dense, almost capitate. The pedicels of the perianth are not at all exserted in either of these species.

Eriogonum Purpusi, n. sp.—Perennial from a branching caudex, the stems densely matted and very short: leaves white-tomentose on both sides, oval to oblanceolate, 3–5$^{\mathrm{mm}}$ long; petiole longer than the blade, dilated below, glabrate on both surfaces but tomentose on the margins: scapes 1–1.5$^{\mathrm{dm}}$ high, lanate at base, glabrous and wiry above: inflorescence a capitulum of six to ten involucres, six to ten-bracteate at base, the inner ones also bracteate: involucres cylindrical-turbinate, about 3$^{\mathrm{mm}}$ long; segments with a thickened glabrous center, margined and united by their scarious portions, which are lightly floccose without and within, and in age give way to the base at the sinuses: perianth glabrous, white with reddish midvein, much exserted, spreading or reflexed, truncate at base; outer segments ovate, exceeded by the oblong inner ones: filaments nearly glabrous: akene obtusely triangular, equalling the perianth, scabrous especially on the angles.

Argus mountains, California, about 5000 ft. altitude, *Dr. C. A. Purpus*, June 1897, no. 5484.

San Diego, Cal.

THE EFFECT OF ETHER UPON THE GERMINATION OF SEEDS AND SPORES.[1]

C. O. TOWNSEND.

IN 1896–7, while carrying on a series of experiments for the purpose of determining the influence of injury upon growth, the writer found that an atmosphere of ether caused considerable variation in the rate of growth of seedlings. The thought presented itself that it would be of interest and of importance to determine the influence of an atmosphere of ether upon the germination of seeds and spores. Accordingly, the following experiments were undertaken and carried on during the winter of 1897–8 in the laboratory of Barnard College. Seeds for the purpose were soaked in pure water for twenty-four hours in ordinary room temperature, and then transferred to air-tight damp chambers, which contained respectively 1, 2.5, 5, and 10^{cc} of ether dissolved in 100^{cc} of water. The damp chambers consisted of bell jars, having a capacity of about four liters each, the sides of which were lined with blotting paper saturated with water. In each series of experiments one chamber contained atmospheric air for control. The seeds used were those of *Zea Mais*, *Avena sativa*, *Phaseolus vulgaris*, and *Cucurbita Pepo.*

EXPERIMENTS WITH SEEDS.

In comparing the normal rate of germination with the germination of seeds in an atmosphere of 1^{cc} of ether, it was found that germination was somewhat accelerated by the ether. The germination in the ether atmosphere began twelve to sixteen hours earlier than in the ether-free atmosphere. At the end of the following five days, however, the growth of the seedlings in the ether-free atmosphere exceeded the growth of the seedlings in the atmosphere containing 1^{cc} of ether, so that the difference in the length of roots of corn varied in the ratio of 35 to 20 in favor of the ether-free atmosphere (table I). With the other seedlings the difference was less marked (tables II, III, and IV). The variation in the growth of shoots or leaves was very slight, being only 14 to 10 and 12 to 9 in favor of the ether-free atmosphere (tables II and III).[2] In tables I–IV the germination was perceptibly hastened by the presence of a small amount of ether in the atmosphere. The advantage was soon lost, however, after the seeds in the control experiment germinated. Even if the seeds in the atmosphere of ether were placed in an atmosphere of pure air as soon as they had germinated, they were soon equaled and often exceeded by the seedlings in the control experiment; hence it is impossible to conceive of any commercial advantage in the use of ether to force the germination of seeds under the conditions of these experiments. It might be mentioned in this connection that in the work of the writer on "The correlation of growth under the influence of injury,"[3] the same conclusions were reached in regard to the influence of a weak atmosphere of ether upon the growth of seedlings.

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[1] Read before Section G, A. A. A. S., Boston, 1898.

In the experiments in which 2.5^{cc} of ether were used it was found, as in the preceding case, that ether exerts a stronger influence upon some seeds than upon others, although in this case the tendency was to retard germination; *e. g.*, corn germinated in an atmosphere containing 2.5^{cc} of ether in the same time that it did in the control experiment, while the germination of oats was retarded fully 48 hours. It would seem in this case that the ether exerted a double influence upon the germination of the corn; one tendency being to hasten the germination, the other to retard it. The two influences, being equal, neutralized each other, producing no visible effect upon the time of germination. In tables II, III, and IV, the tendency to retard pre-

[2] It should be noted that in a consular report for 1896 reference is made to some experiments with ether upon growing plants, in which there seems to have been a very striking degree of acceleration in favor of a weak atmosphere of ether. It is to be regretted that the report does not give a detailed account of the method employed, since the acceleration seems to have been great enough to be of some practical advantage.

[3] Annals of Botany 11*:509–532. 1897.

dominates, hence the time required for the germination of these seeds was prolonged. After germination began, the growth of roots and leaves was retarded by the ether in all of the seedlings.

TABLES I–IV. SEEDS.

Seeds soaked 24 hours in pure water, then placed in damp chamber. Temp. 18° C.

I. Zea Mais.

Cc of ether in chamber	Number of hours required for germination	Total number of hours in chamber	Percentage of germination	Average final length of roots in mm	Average final length of shoots in mm
0	48	168	90	35	14
1	36	168	85	20	10
2.5	48	144	75	12	8
5	96	138	60	8	5
10	no germinat'n	336	0	0	0
II. Avena sativa.					
0	48	168	95	20	12
1	36	168	85	17	9
2.5	96	144	80	11	5
5	96	144	80	8	3
10	no germinat'n	336	0	0	0
III. Phaseolus vulgaris.					
0	40	168	100	18	
1	24	168	100	15	
2.5	68	144	95	8	
5	96	144	85	6	
10	no germinat'n	336	0	0	
IV. Cucurbita Pepo.					
0	36	168	95	18	
1	24	168	95	17	
2.5	60	144	100	15	
5	84	144	50	10	
10	no germinat'n	336	0	0	

When the seeds were placed in an atmosphere containing 5^{cc} of ether, germination was still more strongly retarded; although, as in the preceding case, the effect was greater upon some seeds than upon others. Germination of corn was retarded 48 hours, while oats did not germinate until 144 hours after they were placed in the ether atmosphere, *i. e.*, 48 hours after the corn had begun to germinate under the same conditions. Growth proceeded very slowly in the atmosphere of ether, so that at the end of seven days, while the roots of corn and oats under normal conditions were from 20 to 35^{mm} in length, the roots of corn in the atmosphere of ether measured only from 6 to 10^{mm} and the roots of oats from 4 to 12^{mm} (tables I and II).

In the series of experiments in which 10^{cc} of ether were used it seemed to be impossible for the seeds to germinate, regardless of the length of time they were left in the atmosphere of ether. Some seeds were left fourteen days, and even longer, without showing any signs of germination. Whether the life of the seeds in this strong atmosphere of ether was destroyed or whether vital action was simply suspended, was the point next considered. After the seeds had remained from seven to ten days in the atmosphere containing 10^{cc} of ether, they were transferred to an ether-free atmosphere and placed under the same conditions as the control experiments. At the expiration of forty-eight hours a number of the seeds began to germinate. This was the same length of time required for germination by the seeds in the control experiment; hence it was concluded that the influence of ether for a period of seven days not only did not destroy the life of the seeds, but also did not injure them; *i. e.*, the vital activity of the seeds seemed to be only suspended. When the seeds were left for twelve days in the atmosphere containing 10^{cc} of ether, and were then transferred to an ether-free atmosphere, they seemed to have lost their vitality. It was noticed, however, that after the seeds had remained ten or twelve days in the ether atmosphere, they developed patches of mold (mostly Penicillium), and white and yellow spots, which proved upon examination to be patches of bacteria. However, those seeds which remained free, or comparatively free, from mold and bacteria, seemed to have lost their ability to germinate, showing that it was the influence of the ether, and not of the mold, that rendered the seeds unable to germinate. Similar results appeared both in regard to the inability of the seeds to germinate and in regard to the appearance of mold and bacteria when 15^{cc} of ether were used.

In order to free the seeds from germs and spores of fungi, they were soaked several hours in 0.5 per cent. solution of copper sulfate. A number of seeds were then placed in an ether-free atmosphere, and others in a damp chamber containing 10^{cc} of ether. More than 50 per cent. of the grains of corn that were placed in the ether-free atmosphere germinated in from three to five days, which was double the time required for the germination of similar seeds when soaked in pure water only, Contrary to the preceding experiments, the shoots or leaves appeared first, and attained, in most cases, a length of 5^{cm} before the roots appeared, while in the few seedlings in which the latter did appear, they did not exceed 1^{cm} in length. The oat grains were still more strongly affected by the copper sulfate, and did not begin to germinate until ten days after they were placed in the damp chamber. When the leaves had attained a length of from 2 to 3^{cm} no roots whatever had appeared, while if copper sulfate was not used, the roots appeared first, as in the case of the corn, and attained the greater length. On comparing the behavior of these seeds with those that had been placed in an atmosphere of ether after soaking in copper sulfate, it was found that at the end of four days several grains of corn had begun to germinate, and that none of the seeds remained free from fungi. From the fact that none of the seeds soaked in pure water and transferred to an atmosphere containing 10^{cc} of ether germinated, it would seem that the copper sulfate had a tendency to neutralize the influence of the ether. From lack of time, however, experiments were not carried further in this direction.

EXPERIMENTS WITH SPORES.

The peculiar behavior of the fungi, which often appeared on the seeds in spite of all precautions, called for systematic investigation of the action of ether upon these organisms. Accordingly, several series of experiments were carried through, in which spores of Mucor and Penicillium were used. For these experiments fresh spores were placed upon a mixture of 5 per cent. gelatin and 10 per cent. sugar, and these preparations were then placed in damp chambers, containing respectively 0.1, 1, 2.5, 5, and 10^{cc} of ether, one chamber remaining free from ether for control.

TABLES V, VI. SPORES.

Spores placed on a medium of gelatin 5 per cent., sugar 10 per cent. Temp. 18–20° C.

V. Mucor.

Cc. of ether in chamber	No. hours required for germination	No. hours from germination to formation of new spores	Total duration of experiment (hours)	Appearance of mycelia
0.	14	24	38	Branched
0.1	14	24	38	"
1.	14	24	38	Short and blunt
2.5	24	24	48	Blunt at first, then elong'd
5.	36	24	60	Elongated
10.	*240	No spores	288	Long and branched

VI. Penicillium.

Cc. of ether in chamber	No. hours required for germination	No. hours from germination to formation of new spores	Total duration of experiment (hours)	Appearance of mycelia
0.	12	28	40	Branched
0.1	12	28	40	"
1.	12	28	40	Short
2.5	24	24	48	"
5.	36	36	72	Long and branched
10.	†216	‡264	1440	White, long and branched

*If at end of 240 hours spores were placed on the nutritive medium in an ether-free atmosphere the spores germinated in 14 hours, and in 24 hours a few spore cases and spores had formed.

†Spores in this stage if removed and placed in an ether-free atmosphere grew rapidly and produced new spores in 40 hours.

‡If these new spores were placed on the nutritive medium they germinated in the usual time (12 hours) and produced fruit in 40 hours. The characteristic blue color was present.

The 0.1^{cc} of ether seemed in some instances to accelerate germination slightly. This point was somewhat difficult to determine however, since the normal period of germination does not exceed fourteen hours under the conditions used.

In the damp chamber containing 1^{cc} of ether, many of the spores had germinated at the end of fourteen hours, but the appearance of the hyphæ under these conditions was in strong contrast to those under normal conditions. Instead of being long, slender, and tapering, like normal hyphæ, they were short and blunt, and often enlarged at the ends as if they were growing against some object which was offering resistance. It should be added that at the end of the next twenty-four hours the hyphæ had so overcome the influence of the ether that they had assumed the normal form, size, and stage of development, *i. e.*, they had already produced spores. The fact that these plants had attained the same size as the plants in the control experiments, would indicate that growth must have been accelerated after the first fourteen hours, since at that time they were much dwarfed.

In the chamber that contained 5^{cc} of ether, the spores had simply become enlarged and granular at the end of fourteen hours, and it seemed as if they were unable to push out a tube at any point. At the end of the next twenty-four hours, many of these spores had germinated, and the hyphæ produced were similar in appearance to the hyphæ in the control experiments, except that there was no indication of spores or of spore cases.

When the spores were placed in an atmosphere containing 10^{cc} of ether, germination was retarded for about ten days, at the end of which time many of the spores germinated without removal from the ether atmosphere. If the spores were removed at the end of five days and placed in an ether-free damp chamber, nearly all of them germinated within fourteen hours, but the subsequent growth was not so rapid as it was during the first twenty-four hours in the control experiments. At the end of the second twenty-four hours, the hyphæ showed rapid growth and a few spores were produced, but they were far less numerous than in the control experiments. At the end of ten days when the spores had begun to germinate, some of them were removed and placed in an ether-free atmosphere, and these spores grew more rapidly than those which remained in the ether atmosphere.

The spores of Penicillium grew more rapidly than the spores of Mucor, whether they remained in the ether atmosphere or were removed to an ether-free atmosphere, and in both cases the Penicillium had formed an abundance of spores at the end of thirty-six hours after germination. The Penicillium that had begun to germinate at the end of ten days in the ether atmosphere was left undisturbed during the next twenty days, remaining throughout this time perfectly white, instead of assuming its characteristic bluish-green color, although it was full grown; and the spores had formed in abundance. It was also observed that the patches produced by the fungus did not seem to increase in size, as if the spores formed in the ether-atmosphere had lost power to germinate. When those spores were removed and placed in an atmosphere free from ether, they germinated in about twelve hours, produced fruit in forty hours, and assumed the characteristic bluish-green color. If a still stronger atmosphere of ether was used, *e. g.*, 15^{cc}, the results were practically the same as if only 10^{cc} of ether were used.

CONCLUSIONS.

Since it is evident that an atmosphere of ether of proper strength is capable of preventing the vital action of seeds and spores without necessarily destroying the life of those organisms, it is important to inquire into the cause of this inactivity. Is it due to the inability of the ferment to transform the food material into compounds that may be used by the plants; or is it due to some influence produced upon the protoplasm?

To investigate this first point, definite quantities of starch solution were placed in test tubes to which equal quantities of diastase were added, and also definite quantities of ether, varying from 0.1^{cc} to 10^{cc}. Several test tubes containing no ether were provided for comparison. It was observed that the starch in the tube containing 0.1^{cc} of ether was transformed under the influence of the ether even more readily than in the control experiment, a circumstance that agrees with the observations of Puriewitsch in his interesting work, "Physiologische Untersuchungen über die Entleerung der Reservestoffbehälter."[4] In the other test tubes where larger quantities of ether were used, there seemed to be no appreciable difference in the time required for the transformation of the starch when compared with the control tubes. This also agrees with the observations of Puriewitsch[5] and others; hence it would seem that the inactivity caused by the ether atmosphere is due to the influence produced upon the living protoplasm.

SUMMARY.

1. A weak atmosphere of ether tends to hasten the time of germination of both seeds and spores.

2. A strong atmosphere of ether retards or prevents the germination of seeds and spores.

3. The extent of retardation depends upon the strength of the ether atmosphere up to a given point.

4. The time of retardation for the same strength of ether atmosphere is different for different seeds and spores.

5. Spores produced in a strong atmosphere of ether are able to germinate and to produce new spores as readily as when grown in an ether-free atmosphere.

6. Seeds and spores which are kept from germinating by the influence of ether for several days, will germinate as readily as if they had not been subjected to an atmosphere of ether, if they are removed to an ether-free atmosphere.

7. Ether does not render the ferment inactive.

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[4] Jahrb. für wiss. Botanik 31 : 1–76. 1898.

[5] *Loc. cit.*

BRIEFER ARTICLES.

A NEW TILLETIA PARASITIC ON ORYZA SATIVA L.

(WITH FIGURES 1–4).

In December 1898, Mr. Reid Whitford, United States Engineer, Georgetown, South Carolina, sent the writer a few rice plants affected with a Tilletia. The rice plants were taken from a plantation of 250 acres on the Sampit river, about six miles above Georgetown. Three or four other planters on the same river had rice fields affected with the same disease. Mr. Whitford also sent packages of rice flour ground from normal and diseased rice. The flour made from the diseased grain showed a marked dark color. When examined under the microscope, this flour was found to contain numerous large brownish-black opaque spores, the cause of the dark coloration.

The affected spikelets could hardly be distinguished from the normal ones. The greater number of them showed no signs of disease. When the glumes were broken apart, the affected ovaries were found to be made up of a granular mass of spores.

Professor F. S. Earle, of Auburn, Alabama, has kindly assisted me in the identification of the smut fungus, and found it to be *Tilletia corona* Scrib., first described by S. M. Tracy and F. S. Earle as follows:[1]

> Infesting the ovaries, transforming them into black curved horn-shaped masses, sometimes 1^{cm} in length, the outer covering firm in texture, showing traces of the cellular structure of the ovary; spores large, spherical, 22–26 μ, dark fuscous and densely opaque when mature, but covered with a hyaline envelope 2 μ or more in thickness, the surface of the dark central mass covered by minute but deep alveolations, this structure being obscured by the opacity of the mature spore, when the thin alveolar walls can be seen only at the periphery, where they appear like numerous spinous projections reaching almost through the hyaline envelope. The remains of the fruiting hyphæ often persist on the younger spores as a false pedicel. On various grasses, Mississippi, Illinois, Missouri, and Washington, D. C.

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[1] Tracy, S. M. and Earle, F. S., New species of fungi from Mississippi. Bull. Torr. Bot. Club **23**: 210. 1896.

The following on *Tilletia corona* Scrib., by the same authors, gives the different hosts and localities where this interesting smut has been found:

> This striking smut was first observed by Scribner on *Homalocenchrus oryzoides* and *H. Virginicus* near Washington, D. C., in 1886, and specimens collected by him were distributed by Ellis under the above name in N. A. F., as no. 1896. It has since been collected by Waite in Illinois and Missouri on *Homalocenchrus*, on *Panicum virgatum* in Illinois, and by the writers in Mississippi on *Homalocenchrus lenticularis* and *H. Virginicus* at Columbus, on *H. lenticularis* at Bairds, and on *Panicum sanguinale* at Starkville. Specimens on *Panicum virgatum* in the herbarium of the Division of Vegetable Pathology at Washington bear the unpublished herbarium name *Tilletia pulcherrima* Ell. & Gal., but they seem identical with the forms on the other hosts.

The Tilletia infesting the ovaries of the rice plant agrees in most respects with the above description of *Tilletia corona* Scrib. The ovaries become transformed into a black, granular mass of spores. They are, however, seldom hypertrophied or atrophied, but retain to a great extent the form and size of the normal ovaries. They are never curved like the affected ovaries of the other hosts of *Tilletia corona*.

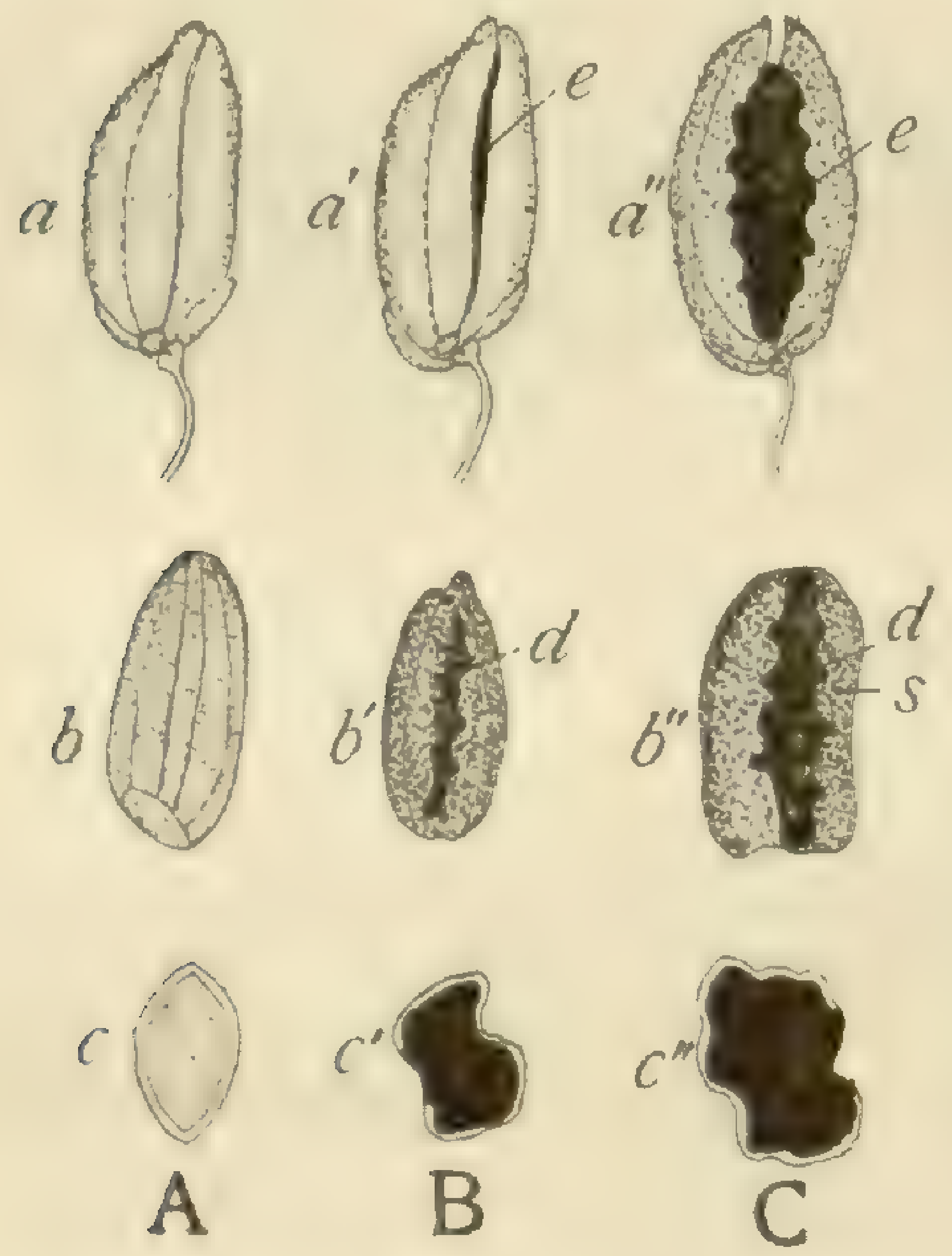

FIG. 1.—*A: a*, normal rice spikelet; *b*, the normal rice grain after the glumes have been removed; *c*, cross section of a normal grain.

B: a', an affected spikelet the glumes of which have been partly pressed apart, exposing the spore mass, *e*; *b'*, after the glumes have been removed, spore mass exposed at *d*, the fissure in the original ovary wall; *c'*, cross section of a smutted grain filled with spores.

C: a", an affected spikelet, the ovary of which has been partly hypertrophied; *b"*, after the glumes have been removed, showing *d*, the fissure in *s*, the original ovary wall; *c"*, cross section of the destroyed grain.

As is well known the two glumes of rice spikelets are hard, cover firmly the whole ovary, and remain attached to it when mature. In smutted panicles the affected spikelets are hardly distinguishable from the normal ones, since the destroyed ovaries remain inside of the two glumes, seldom pressing them apart by increased size. The normal and smutted spikelets are often so much alike in their external characters, that when searching for smutted grains in a panicle containing diseased ovaries, diseased spikelets are often mistaken for normal ones. In many spikelets, however, the ovaries become hypertrophied and the two glumes are pressed apart, exposing the grayish or dark destroyed ovary (*fig. 1, C*).

Many ovaries have been but partly destroyed. In these, parts of the grain still remain, while the other parts have been converted into a mass of spores. The greater number have been entirely replaced by the fungus spores. In the totally destroyed grains the spore mass is inclosed only by the epidermis and very thin original wall of the ovary, which is not firm in its texture but can be easily torn off, exposing the black mass beneath (*fig. 1, C, b″*). The affected ovaries are often more shrunken and grooved, otherwise usually of the same size as the normal.

The spores are large and spherical, sometimes broadly elliptical. They are surrounded by a hyaline, cuticle-like envelope, 2–3 μ thick. The diameter of the spores, including this hyaline envelope, is from 26–30 μ. The color of the spores varies from a deep brown to black. They are covered with numerous projections from the wall, giving them a spinous appearance. These projections extend almost through the hyaline cuticle-like covering. They can be seen best on the less opaque spores. On the opaque spores the projections can be seen only at the periphery. These projections or spines vary in size and form in different spores; sometimes being pointed and curved, but usually more or less blunt. The spores form one granular homogeneous mass inside of the ovaries, with here and there traces of short pieces of mycelium. Two sizes of this mycelium are found. First, broken pieces of brownish septate hyphæ, 4–6 μ in diameter (*fig. 2, m*). Second, smaller hyphæ, 2–3 μ in diameter, which are sometimes found attached to the spores (*fig. 2, e*). The larger hyphæ are apparently remains of the vegetative mycelium, while the smaller ones are remains of the fruiting or sporogenous hyphæ

Mixed with the mature spores are also found numerous remains of immature spores which have been arrested in their growth. These spores are found in different stages of development. The less developed ones consist only of a shrunken, hyaline cell wall with no contents, projections, or thickenings (*fig. 2, c, d*). In the more developed ones the cell wall appears to be pitted or unequally thickened, many of them showing the projections. They are often filled with granular cell concontents and a nucleus. That they are spores which have been arrested in their growth, there can be no doubt. In *fig. 2. d, e,* are shown two mature spores and two immature ones, all four of them apparently connected by the same fruiting hypha. Out of thirty mounts only one was found to contain the hypha still remaining attached to the immature spores. The immature spores are more numerous in ovaries which have been completely destroyed and converted into spores. They are not so numerous in ovaries that still contain parts of their starch contents. Often 15 to 20 per cent. of the spores incompletely destroyed ovaries are immature and undeveloped, showing that the arrested development of these spores is due to an impoverished nutrition, and probably also to the lack of sufficient space for their complete development.

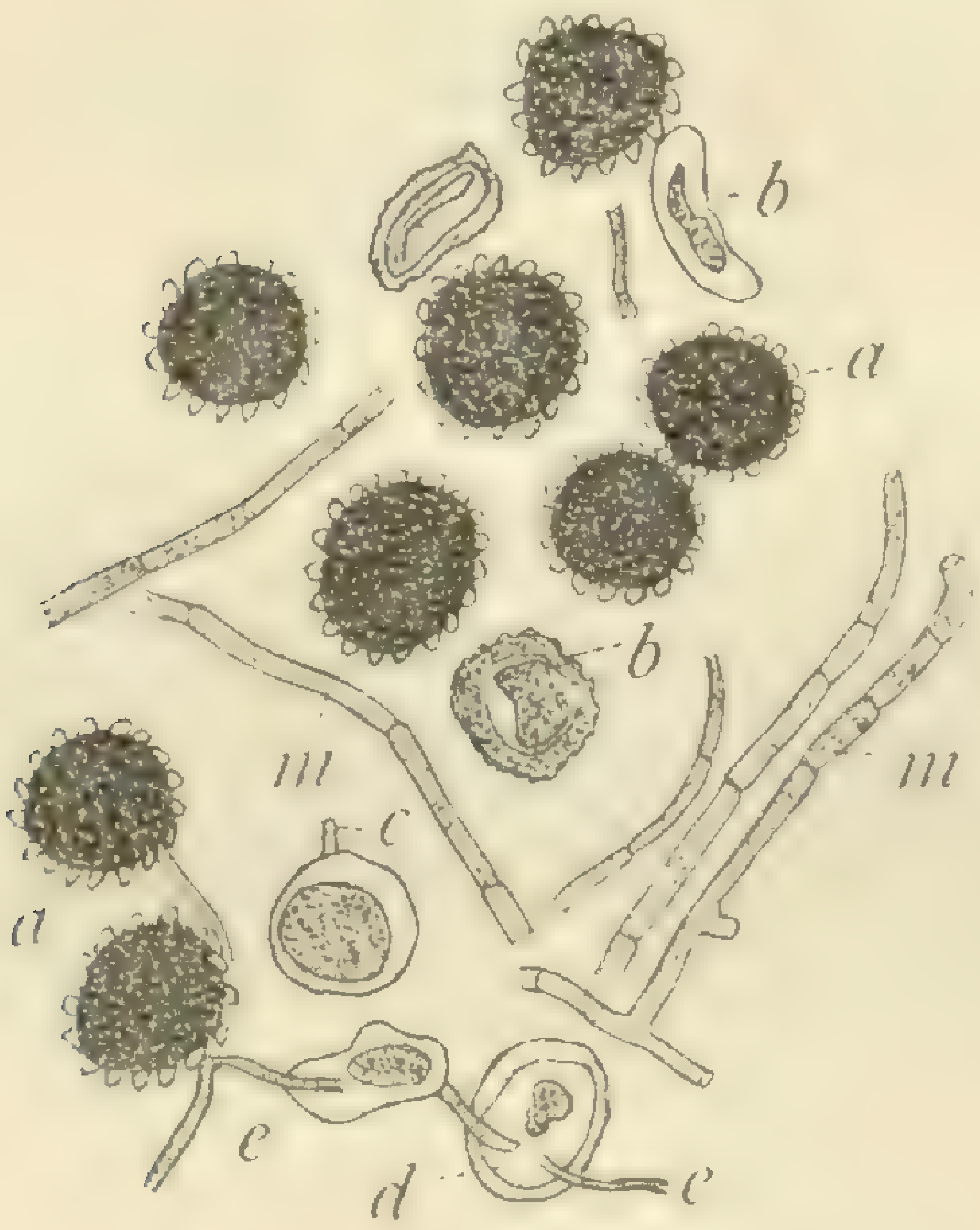

FIG. 2.—*a*, mature spores; *b*, immature spores; *c*, an immature spore with remains of the fruiting hypha; *d*, two immature spores connected with what appears to be a sporogenous or fruiting hypha; *m*, broken pieces of mycelium, evidently remains of the vegetative hyphæ.

Cross and longitudinal sections of the culms were made with a view to finding the smut mycelium and to determining the probable mode of infection. Cross sections of the culms, eight inches below the panicles of the diseased rice plants, showed the presence of a mycelium similar in every respect to the larger one found in the destroyed ovaries. This mycelium is found only in the sub-epidermal vertical rows of loose chlorophyll parenchyma, which lie beneath the rows of stomata in the epidermis. In *fig. 3, B,* are shown bits of mycelium at *m*. The loose chlorophyll parenchyma is connected with the stomata at *g*. In *fig. 4*, the same mycelium is shown in a longitudinal section of the rice culm, eight inches below the panicle.

In cross sections of a rice culm, about one half of the sub-epidermal tissues are stereome, lying between the strips of chlorophyll parenchyma (*fig. 3*, *A*, *c*, and *B*, *s*). The mycelium is never present in this stereome, nor in the fibro-vascular bundles and colorless parenchyma in the interior of the culm.

Cross and longitudinal sections of the rachis also showed the presence of the same mycelium.

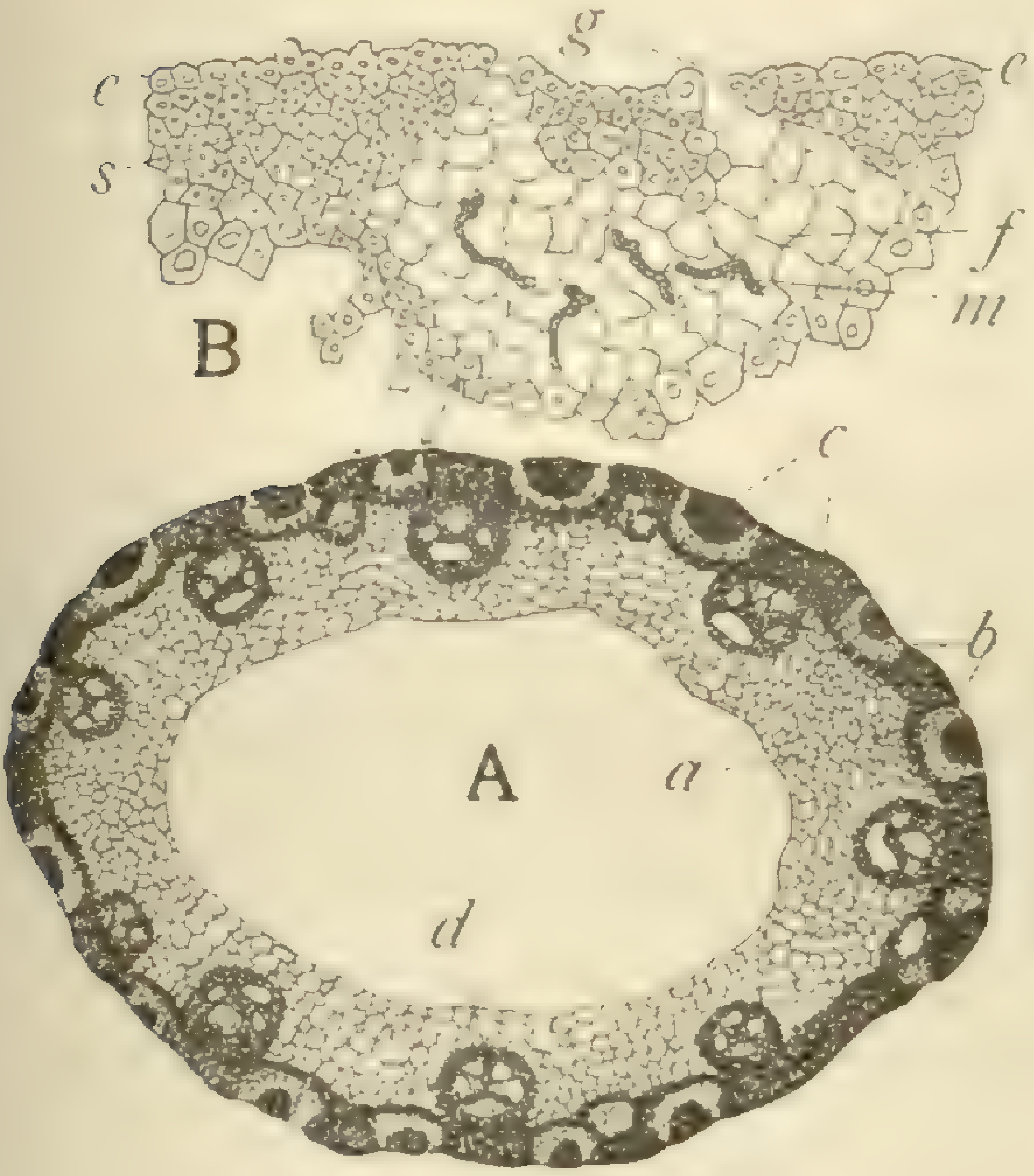

FIG. 3.

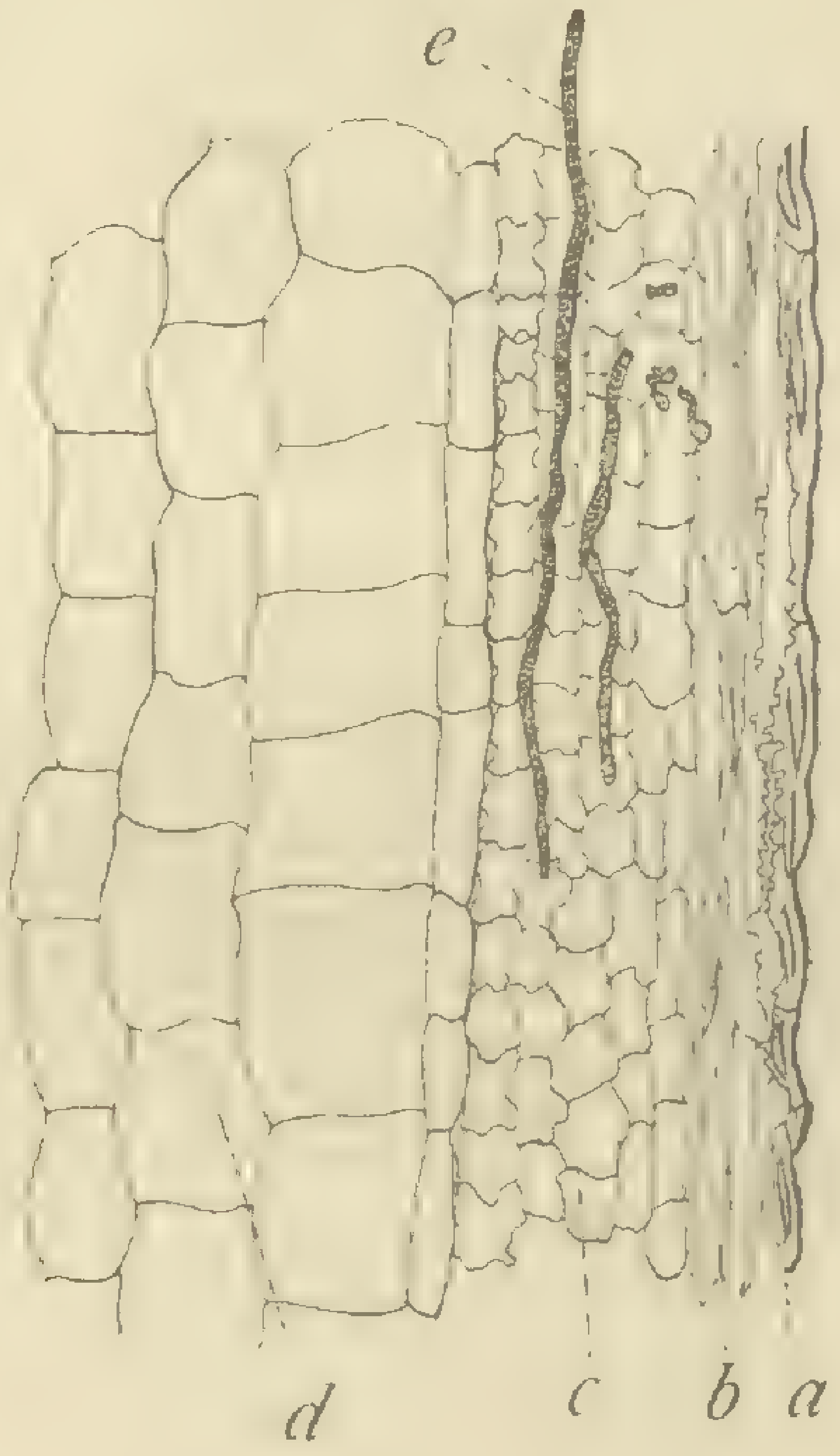

FIG. 4.

FIG. 3.—*A:* Cross section of a rice culm with diseased spikelets, about eight inches below the panicle; *a*, colorless parenchyma; *b*, chlorophyll parenchyma; *c*, stereome; *d*, fibro-vascular bundles.

B: Magnified portion of stereome and chlorophyll parenchyma areas; *e*, epidermis; *f*, chlorophyll parenchyma; *g*, two stomata; *m*, mycelium; *s*, stereome.

FIG. 4.—Longitudinal section of a rice culm about eight inches below the panicle; *a*, epidermis; *b*, stereome; *c*, chlorophyll parenchyma; *d*, colorless parenchyma; *e*, mycelium.

The presence of this mycelium in the rice culms shows, no doubt, that this smut infects the rice plant in the same way that *Tilletia lævis* Kühn and *T. caries* Tul. infect the young seedling at the time of the germination of the wheat grain.

I have not been able, as yet, to germinate the spores, hence no infection experiments have been performed.

As far as I know, no smut has heretofore been reported on the rice plant in America.

In 1896, Y. Takahashi described a new species of Tilletia (*T. horrida*) on the rice plant in Japan,[2] as follows:

> Spore-masses pulverulent, black, produced within the ovary and remaining covered by the glumes. Spores globose, irregularly rounded, or sometimes broadly elliptical, the round ones 18.5–23 μ in diameter, and the elongated ones 22.5 – 26 × 18 – 22 μ in size.
>
> Epispore deep olive-brown, opaque, thickly covered with conspicuous spines. The spines hyaline or slightly colored, pointed at the apex, irregularly polygonal at the base, more or less curved, 2.5 – 4 μ in height, and 1.5–2 μ apart at their free ends. Sporidia filiform or needle-shaped, curved in various ways, 10–20 in number and 38–53 μ in length. *Hab.* On *Oryza sativa* L. From Tōkyō and Kyōto.

By comparing the descriptions of *T. horrida* Tak. and *T. corona* Scrib., it appears that the two are identical; agreeing not only in their size, but in their other characters as well, except that attempts at germinating the spores of *T. corona* have, as yet, given negative results.

One other Tilletia, *T. Oryzæ* Pat., has been reported on the rice plant.[3] It forms spores 3–5 μ in diameter. Brefeld has made a careful study of *T. Oryzæ* Pat., and found it to belong, not to the Ustilagineæ, but to the sclerotia-forming Ascomycetes, since it forms sclerotia inside of the rice grain.[4]

I am indebted to Dr. A. C. True of Washington, to Director Wm. Trelease, and to Mr. J. B. S. Norton, of the Missouri Botanical Gardens, and to Professor F. S. Earle, of Auburn, Alabama, for kindly supplying me with references.—ALEXANDER P. ANDERSON, *Clemson College, S. C.*

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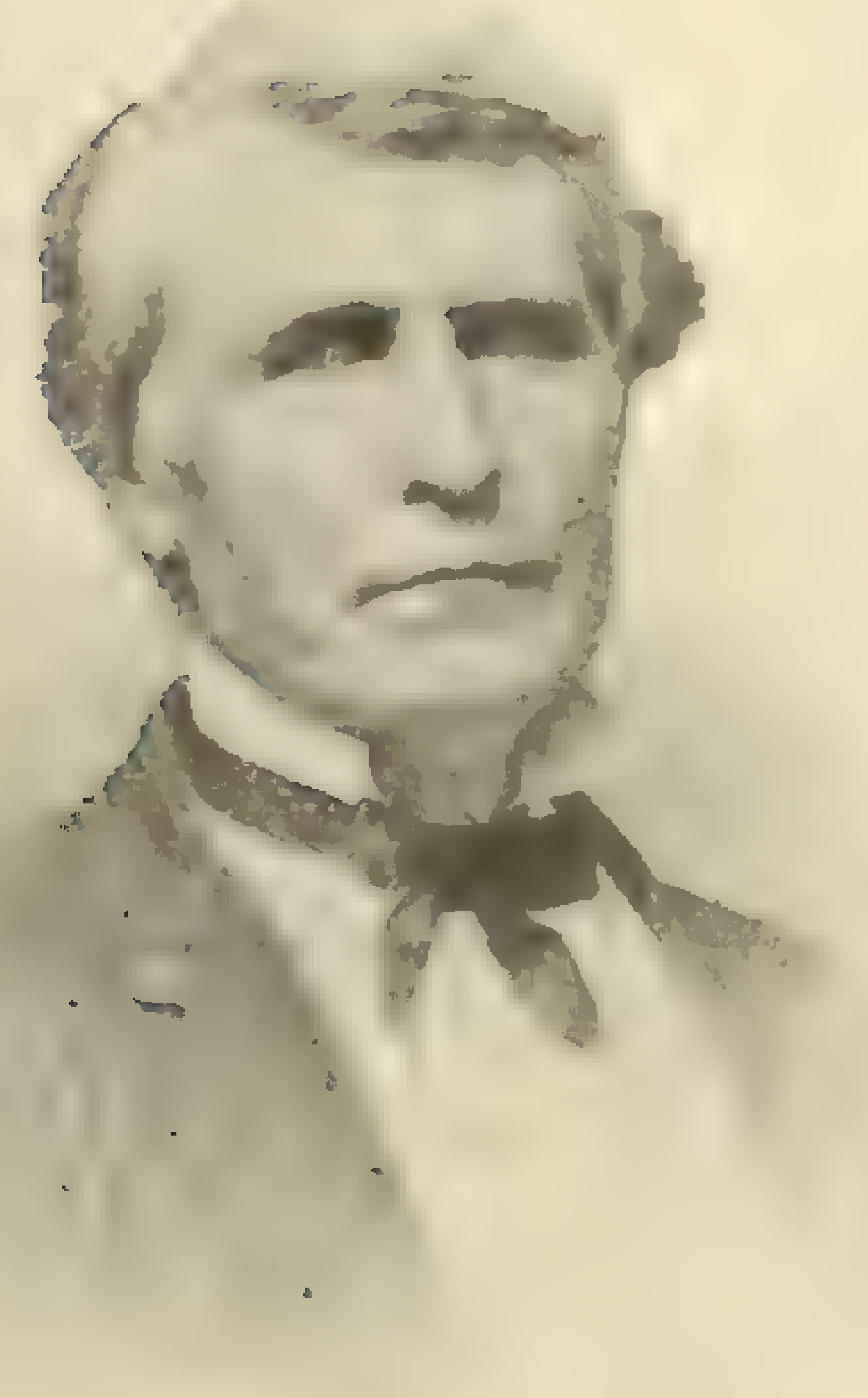
[2] TAKAHASHI, Y. On *Ustilago virens* Cooke and a new species of Tilletia parasitic on rice-plant. Tōkyō Bot. Mag. **10**: 20. 1896.

[3] PATOUILLARD, Champignons extra européens. Bull. Soc. Myc. France **3**: 124. *pl. 10. fig. 2.* 1887.

[4] Bot. Centralblatt **65**: 97. 1896.

ALVIN WENTWORTH CHAPMAN.

(WITH PORTRAIT)



DIED, April 6, after an illness of a brief hour, at Apalachicola Florida, Alvin Wentworth Chapman, B.A., M.D., LL.D., at the age of eighty-nine years and seven months.

With his demise passed away the Nestor of American botanists, the last of the active workers to whom the great progress made during the past sixty years in the exploration and investigation of the flora of this continent is to be ascribed.

Dr. Chapman left a short sketch of his life, written about a year before his death, which we give here in his own words:

A BRIEF OUTLINE OF THE HISTORY OF MY LIFE.

I was born, the youngest of a family of five children, on the twenty-eighth day of September 1809, at Southampton, in the state of Massachusetts, of English parentage; my paternal ancestor emigrating from the north of England, and my maternal from the Pomeroys of Devonshire.

I attended the public schools of the town for eight years, and then commenced the study of classics preparatory for entrance upon a collegiate course, and in 1826 joined the class of that year at Amherst College, graduating with honor in September 1830. In May of the following year I came to Georgia as a teacher in a family on Whitemarsh island near Savannah, and two years afterwards was elected principal of the academy at Washington, in Wilkes county, where I commenced my professional studies with Dr. Albert Reese of that county. In the winter of 1835, at the solicitation of the late Dr. Nicholson, of Gadsden county, I came to this state, which has been my residence ever since; first at Quincy, then at Marianna, and since 1847 in this city.

My life has been uneventful, and I am known mainly beyond the limits of this city as a botanist, and the author of the *Flora of the Southern United States*, which has received the approbation of botanists both at home and abroad.

At my great age I find myself the sole remaining representative of my race, my college class, my scientific correspondents, and all the business fraternity of this city in its former palmy days.

In 1839 I married at Marion, a Mrs. Mary Ann Hancock, of New Bern, North Carolina, who died at Rome, Georgia, in 1879, and I have no surviving children.

A. W. CHAPMAN, LL.D.

Apalachicola, March 13, 1898.

While engaged in the practice of his profession, Dr. Chapman was closely identified with the public interest of his fellow-citizens. He filled the place of mayor and collector of customs from 1866 to 1870. Outside of these duties his spare time was given to his botanical pursuits, involving a voluminous correspondence with his scientific contemporaries. In acknowledgment of the merit of his labors he received honorary degrees from scientific associations in this country. In 1854 he was made a member of the New Orleans Academy of Science; in 1861 of the Philadelphia Academy of Natural Science; in 1866 of the Buffalo Society of Natural History and associate fellow of the American Academy of Arts and Sciences; and in 1895, honorary member of the Botanical Society of America.

Dr. Chapman was in every respect a perfectly normally constituted man, of fine physique, and dignified appearance, robust in health, vigorous, and of untiring activity, which he retained almost unimpaired to the end of his years. He was remarkably free from interruptions by the ills man is generally heir too. The following incidents might serve as an illustration of the great physical and mental energy by which he was animated after he had already passed, by several years, the eighth decade of his life, and which will ever be cherished in the memory of the writer. When the deceased presented to me specimens of the beautiful and rare orchid, *Calopogon multiflorus*, he dictated a note to be made on the label, "Collected by A. W. Chapman, walking thirteen miles for this plant, in his eighty-third year." In the fall of 1895 he accompanied the writer on a tedious trip made in a small skiff many miles up the Apalachicola river in search of an obscure ash which he observed thirty years before, but had not encountered afterwards. This he at once pointed out again. In March 1898 he joined Professor Sargent and the writer on a trip in a tow boat to the same localities. During the whole day, spent in the almost inaccessible palmetto and cypress swamps, our aged companion showed the alacrity of the botanical collector in the best years of life.

At that time he looked hopefully forward to a busy season in the field, making preparations for a repeated and thorough investigation of the Torreya region on the Apalachicola river, one of the most interesting localities in the southern states. This had yielded to him in former years a harvest of many new and interesting plants, and he was sure it harbored others equally interesting and yet unknown, hidden in the dark ravines and steep hillsides, under the shade of the Torreya and Taxus peculiar to this secluded spot. He left his home fully equipped for a long stay in the field. With the progress of the warmer season he was soon convinced that the work in such rugged territory under a subtropical sun was beyond his strength; several attacks of vertigo admonished him of the danger of sudden heart failure, so he relinquished this task and his anticipated pleasures, to spend the summer at his home under the tender care of a granddaughter of his wife, Miss Kate Wood. He soon recovered from the exhaustion caused by this last attempt; his step was yet firm and he enjoyed to the last his daily walks. The end, however, was near. It came suddenly, although at his great age to be expected at any hour, after a day of the usual quiet and happiness which he enjoyed in the evening of his life. In the afternoon of April 6 he was taken down by heart trouble, and before those around him could realize that death had laid its hand upon him, he passed away quietly and peacefully as he had lived.

The love and esteem in which this amiable, unassuming, yet firm and active character was held by his fellow-citizens was shown when he was laid down to his last rest. He was looked upon with veneration as the last one among them who linked the past with the present, as the last survivor of a generation which had enjoyed the palmy days of prosperity, who stood by them throughout the throes of the birth of the new future, which has now dawned upon the rising generation. All the industrial establishments and most of the places of business were closed to give everyone a chance of paying the last honor to the departed.

From a lady, a few years past an inmate of his house, we learn that "his writing was done with most beautiful precision, and the accuracy of his memory, his vivid powers of description, and impressiveness of manner made his narrative of events like a mental picture." The only faculty that failed him was his hearing, and about this he was so sensitive as to become in late years somewhat a recluse.

Dr. Chapman's interest in natural science brought him in contact with the Smithsonian Institution, soon after its inauguration, by his entomological and meteorological work. He furnished to the Institution the first specimen of the chrysalides of some of the butterflies of Apalachicola, with a report upon their plant food. At that time he had a large collection of southern lepidoptera. His spare time, however, was soon altogether devoted to botanical work, by which he became most widely known in the scientific world. Disinclined, by his unassuming disposition, to speak about himself, little is known of the beginning of his botanical career. There is no doubt that it received a great impetus in his meeting Mr. Stephen Croom which took place soon after Dr. Chapman had entered upon the practice of his profession at Marianna in 1839. A wealthy planter, possessing plantations near that place and Aspalaga, Fla., Mr. Croom had given great promise as a botanist by his discovery of *Torreya taxifolia* and by his monograph of Sarracenia. This acquaintance led to a close friendship until the sad death of Mr. Croom, who perished, with his wife and all his children, in the foundering of the ill-fated ship "Home" between New York and Charleston. By this accident the plans for the thorough exploration of Florida in connection with Dr. Chapman were frustrated.[1]

From the time of his settling in Quincy, Fla., the Doctor became a frequent contributor of plants from this section to the authors of the *Flora of North America*, Drs. Torrey and Gray, and their life-long friend. In their work they dedicated an interesting genus of the western coast of Florida, as they remarked, "to our friend Dr. A. W. Chapman, an accurate and indefatigable botanist, who largely contributed to our knowlege of plants from middle Florida.[2]

After the publication of Gray's *Manual of the Botany of the Northern United States* (1848), the want of a work on a similar plan, giving an account of the southern states east of the Mississippi, was severely felt by botanists, by authors as well as by the students, in the field and the classroom, and particularly in the South, its botanical realm being almost unknown and without a guide. Urged by their contemporaries, the Rev. Dr. M. A. Curtis, of North Carolina, was to join Dr. Chapman in the undertaking of writing a flora of the southern states. Deeply engaged upon southern mycology and under the pressure of the duties of his calling, Mr. Curtis had to withdraw from this task, which thus fell to the sole charge of Dr. Chapman. He certainly must have entered upon it with great zeal and industry. As stated in the preface to the third edition of his work "with the limited equipment for such an undertaking and fully occupied in the discharge of my profession, in moments of leisure during three or four years, the task was completed, given to the press and favorably received by my contemporaries both at home and abroad." How formidable this task was, is still more apparent when it is considered that, at that time, Florida and the state to the west of it were a veritable *terra incognita* to the botanist. Strongly impressed with the necessity of meeting more fully the requirements of a flora of the southern states he had to extend the region of the flora beyond the limits of the Carolinas and Georgia, to which his attention had been chiefly directed, and to bring within its scope all the states south of Virginia and Kentucky east of the Mississippi river.

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[1] Sargent: Scientific papers of Asa Gray 2: 195.

[2] Torrey and Gray: Flora N. Amer. 1: 355. 1840.

Gifted with a strong memory, high powers of observation, and acute discrimination, patient and unwavering in the effort to arrive at the truth, of an untiring industry, knowing no fatigue in the field and in the precise record of his observations, he entered upon his task well fitted indeed. His descriptions are vivid, concise and clear, intelligible to the general student and the beginner, giving his book the merit of popularity besides its scientific value. The establishment of his genus Leitneria, and its exposition as the single type of an interesting natural order, evinces the scientific turn of mind and the method required for enduring work in phytography, which secured to the author a place in the ranks of the writers of authority on systematic botany.

How well he succeeded in his work is proven by the favor with which it was received. In 1883 appeared a second edition, a reprint of the first with a supplement containing the descriptions of the plants which became known to the author during the interval of twenty-three years since the first appearence of the book, including about 550 species and varieties, of which 26 had not been described before. Untoward circumstances caused a long delay in the issue of a third edition anxiously looked for by all interested in American botany. It finally appeared in the beginning of 1897. The plan and nomenclature of former editions were strictly adhered to. As the author says in his preface, "the addition of new matter accumulated since, made condensation and abbreviation of portions of former editions imperative in order to retain the volume within the handy limit;" adding, further, that many new species proposed by recent collectors, when fully confirmed, will have to find a place in future issues.

Besides the *Flora of the Southern United States*, Dr. Chapman's publications in the journals were few. They comprise the following papers, all of which appeared in the BOTANICAL GAZETTE:

An enumeration of some plants, chiefly from the semi-tropical regions of Florida, which are either new, or which have not hitherto been recorded as belonging to the flora of the southern states. BOT. GAZ. 3:2, 9, 17. 1878.

Torreya taxifolia, a reminiscence. BOT. GAZ. 10:254. 1885.

In volume 11:132. 1886, he published a brief note in reference to the preparation of herbarium specimens.

Dr. Chapman has endeared himself to all who applied to him for information by the readiness with which he generously responded. The cordial welcome extended to his visitors, his courteous bearing, the genial warmth of heart and mind will ever be kept in grateful remembrance by those who enjoyed his personal acquaintance.—CHARLES MOHR, *Mobile, Ala.*

WHAT IS PRUNUS INSITITIA?

THIS species[3] seems to have been a puzzle ever since Linnæus published it. It has been a stumbling block to all American botanists who have not been able gracefully to avoid it. For a long time I have been trying to find *Prunus insititia*, until recently I decided to give the matter a thorough overhauling. It seems to me that it is time to lay this species name to its final rest, and the following remarks are offered in the hope of contributing to that result.

The term *insititia* has been translated grafted, and it has been said that Linnæus meant to characterize under this name the grafted garden plums as distinct from the seedling forms of *Prunus domestica* which he knew; but Koch[4] gives a different and more plausible interpretation. He says "the word *insititia* means here exotic, in distinction from the Sloe which Linnæus had seen wild in Sweden." Unfortunately we are obliged to depend largely on outside evidence for our knowledge of what Linnæus meant to include in his *Prunus insititia*, the only direct testimony being the original description cited herewith. In elucidating this matter we would naturally expect help from the botanists of the land where the species was said to grow. But the views taken by European botanists of this species are striking in their varied disagreements. I will mention only a few of the more important. To appreciate their discrepancies it is necessary to remember that, as we understand *Prunus domestica* Linn. in this country, it includes all the cultivated plums of European origin except the Myrobalans. The latter may be disregarded here, since they take no part in the confusion. Thus, with the unanimous consent of American botanists and horticulturists, *P. domestica* includes the various Green Gages, Perdrigons, Prunes, St. Catherines, St. Juliens, etc , and, what is of more interest here, the Damsons.[5]

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[3] *Prunus insititia* Linn. Amoen. Acad. 4:273. 1755. The original account, as given by Linnæus, is as follows:

PRUNUS (*insititia*) spinosa, foliis ovatis subtus villosis, pedunculis geminis.

Pruna sylvestria præcocia, Bauh. Pin. 44.

Prunus sylvestris major, Raj. Hist. 1528.

Habitat in Anglia, Germania.

Descr. Arbor magnitudine Pruni domesticæ. Rami fusco-rubri, læves; ramuli nonnulli spina terminati. Stipulæ lineares, ciliatæ, acutæ, basi bifidæ, nec ut in P. domestica simplices et indivisæ. Folia ovata, supra glabra, nec ut in domestica subvillosa, subtus villosa. Gemmæ floriferæ promunt pedunculos duos, ut in domestica. Calyces glabri, nec villosi ut in domestica.

Koch[6] wrote in his Dendrologie (1869), "There is no doubt that this species grows wild in Central Europe;" but in his Obstgehölze[7] (1876) he says, "It is a Damson run wild." In the former connection he says, "All the cultivated varieties of the true Damsons belong here, also many Damson-like Prunes. Others may be crosses between the Damsons and the Prunes."

Loudon,[8] speaking of *Prunus insititia*, said, "This may be a variety of *P. spinosa*."

Bentham[9] put *Prunus domestica*, *P. insititia*, and *P. spinosa* all into *P. communis* Huds.

Lucas[10] refers the true Prunes to *Prunus domestica*, and puts into *P. insititia* the Sloe or Bullace (Krieche oder Haferpflaume) and the St. Julien.

Nicholson[11] gives *Prunus domestica*, *P. insititia*, and *P. spinosa* separately.

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[4] Dendrologie 1:95. 1869.

[5] Cf. F. A. Waugh, Early Botanical views of *Prunus domestica* Linn., BOT. GAZ. 26:417. 1898.

[6] Dendrologie 1:95. 1869.

[7] Deutsche Obstgehölze 142. 1876.

[8] Arb. Frut. Brit. 2:687. 1854.

[9] Handb. Brit. Fl. 1:236. 1865.

[10] Einleit. Stud. Pom. 3. 1877.

[11] Dict. Gard. 3:236. 1887.

Schwarz[12] refers the Prunes to *Prunus domestica*, and says under *P. insititia* that the Reine Claudes (Green Gages), Mirabelles, and Damsons are derived from this stock.

Dippel[13] says the species is distributed from south and middle Europe to the Orient and the lands of the Caucasus. He says it is the progenitor of the Damsons, and he also refers several cultivated ornamental plums to it.

In this country the species has been more commonly ignored. Gray[14] seems to have been the first to give it a place, and he made it a variety of *Prunus spinosa*. This disposition of the case has been recently adopted by Britton and Brown.[15] Sargent[16] mentions *P. insititia* incidentally, as though it were a species well known in cultivation, but has given it no discussion, so far as I know.

Through the kindness of the curators I have been enabled recently to examine the material in the herbaria of Columbia University, of the Missouri Botanical Garden, and in the United States National Herbarium. The study of these specimens, taken with the literature of the subject, points clearly to the conclusion that there is no such species as *Prunus insititia*. A considerable portion of the material is referable without doubt to *P. spinosa*, and the remainder with even greater certainty to *P. domestica*. This latter portion, which includes the only forms which may give trouble, seems to represent quite clearly the Damson section of the Domestica group. In other words, *Prunus insititia* Linn. is doubtless a synonym of *P. domestica Damascena* Linn.

When *Prunus insititia* has been given in the botanical manuals of the United States, it has been referred to eastern Massachusetts, usually as "adventitious in hedgerows." When I wrote to Professor Sargent to ask about specimens in the herbarium of Arnold Arboretum he replied: "*Prunus insititia* has always been a puzzle to us, and numerous searches for this tree at the station where it is reported to grow in this neighborhood have proved fruitless. It is not represented at all in our herbarium, and if you succeed in finding any authentic material, I should be glad to see it." In the Torrey herbarium at Columbia University there are several specimens from Cambridge, Mass., and vicinity, but they are all *Prunus spinosa*. Another from the same locality in the National Herbarium is a duplicate of one of the Torrey herbarium specimens. As this material dates back directly to the time of Dr. Gray, and as it comes from the stations specified by him, it seems hardly doubtful that this was what he had in hand when he included *Prunus spinosa insititia* in the Manual. This would make Gray's name a synonym of *P. spinosa* Linn.

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[12] Forst. Bot. 339. 1892.

[13] Laubholzkunde 3: 639. 1893

[14] *Prunus spinosa insititia* Gray, Man. Bot. 112. 1856 [ed. 2]. In the first edition of the Manual (p. 114, 1848), however, Gray called this *P. insititia* L.

[15] Ill. Fl. 2: 250. 1897.

[16] Silva N. A. 4: 9. 1892.

Besides the names already mentioned Walter[17] described a *Prunus insititia* which is referred to *P. angustifolia* Marsh by Sudworth.[18]

The case may be summed up as follows:

Prunus insititia of Linnæus and later European authors is mostly P. DOMESTICA DAMASCENA Linn., other groups of *P. domestica* being sometimes included.

Prunus spinosa insititia Gray is P. SPINOSA Linn.

Prunus insititia Walt. is P. ANGUSTIFOLIA Marsh.—F. A. WAUGH, *University of Vermont, Experiment Station.*

AN UNDESCRIBED BIRCH FROM ALASKA.

Betula Kenaica, n. sp.—Arborescent, 10 to 15^{m} high, often widely spreading: trunk 0.3 to 0.5^{m} in diameter, bark rough and more or less furrowed, on the younger branches dark reddish-gray or brown, not scaly or only slightly so, twigs not resin-dotted: leaves ovate, acute or acuminate, wedge-shaped at base or somewhat rounded but not cordate, irregularly and somewhat sharply toothed, the teeth appearing as if gland-tipped, smooth or nearly so on both surfaces, under side lighter in color; petioles slender, 10 to 20^{mm} commonly about 15^{mm} in length, blade 35 to 50^{mm} usually about 40^{mm} long and 30^{mm} wide: flowering catkins not seen; fruiting catkins 20 to 30^{mm} in length, oblong or nearly cylindrical, mostly erect on short peduncles; scales 2 to 4^{mm} broad and 5 or 6^{mm} long, deeply 3-lobed, the lateral lobes rounded and divergent, the central one considerably longer, acuminate, sometimes recurved, ciliate or glabrate: fruit 2 to 2.5^{mm} broad including the wings, which about equal the body, and 2 to 3^{mm} in length.

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[17] Fl. Carol. 146. 1788.

[18] Nom. Arb. Fl. U. S. 237. 1897.

Alaska on the Kenai peninsula in the vicinity of Cook inlet and perhaps elsewhere. Numbers 492 from Sunrise at the head of Turnagain arm and 664 from Kussiloff, on the western side of the peninsula, 1897 and 1898.

This apparently very distinct birch was first noticed by me in the summer of 1897 at Sunrise, a small mining camp near the head of Turnagain arm. It was seen at other places, usually associated with *Picea Sitchensis* and what was then considered *Betula papyrifera*, but the two birches seemed quite distinct. This tree is locally known as the red or black birch, and its rough bark and nearly unlaminated younger growth quickly distinguish it from the other species. In general appearance the trunk of an old tree bears a striking resemblance to that of *Prunus serotina*. In 1898 I again visited this region and found this tree abundant at Kussiloff, about 50 miles from the mouth of Cook inlet and it was later observed elsewhere, seeming to indicate its general distribution over the Kenai peninsula, at least on its western side. The material from which this description has been drawn was compared with the collection of the National Herbarium and that of the Arnold Arboretum and was found very distinct. It was also compared with the collection at St. Petersburg and pronounced unlike any Siberian or other material in their possession. To those in charge of the above collections I wish to acknowledge my indebtedness.—WALTER H. EVANS, *Office of Experiment Stations, Dept. of Agric., Washington, D. C.*

OPEN LETTERS.

A BRYOLOGICAL MEMORIAL MEETING.

COLUMBUS, Ohio, was the home for many years of William S. Sullivant and Leo Lesquereux, two names which will always awaken love and reverence from all students of North American mosses and hepatics. It is twenty-six years since Sullivant died, and this last quarter of the century has seen a marked extension of the limits of bryological study and a large increase in the number of students. It seems a fitting time and place to take a survey of the field, review the past and make plans for the future; hence it is proposed to make the coming meeting of the American Association for the Advancement of Science, which is to be held at Columbus, August 21–26, the occasion for a Memorial Day in honor of the Nestors in American bryology. It is proposed to present a series of historical papers, illustrated by photographs, specimens, microscopical exhibits, and literature showing the bryological work of Hedwig, Palisot de Beauvois, Michaux, Muhlenberg, Bridel, Torrey, Drummond, Hooker and Wilson, Greville, Sullivant and Lesquereux, James and Watson, 'Austin, Ravenel, Wolle, Faxon and Eaton. Supplementing these there will be shown collections of specimens, macroscopic and microscopic, illustrating the monographic work of recent American students. If foreign students who have worked on North American bryophytes can be persuaded to cooperate with us, the following will be asked to contribute: Bescherelle, Brotherus, Cardot, Dixon, Kindberg, Mitten, Pearson, Röll, Stephani, and Warnstorf. An effort will be made to secure the loan of type specimens and illustrations from the following sources: Academy of Natural Sciences of Philadelphia, Academy of Sciences of New York, Columbia University, Geological and Natural History Survey of Canada, Harvard University, National Museum, Ohio State University, University of Wisconsin, and Yale University, as well as from private herbaria and collections. It is also requested that any portraits, autograph letters, type specimens, and drawings of special interest, as well as presentation copies of books and pamphlets, be loaned for the occasion. The following committee of organization will gladly answer any questions and give assistance to those wishing to contribute.

MRS. N. L. BRITTON, *New York Botanical Garden.*
PROFESSOR W. A. KELLERMAN, *Ohio State University.*
PROFESSOR CHARLES R. BARNES, *University of Chicago.*
DR. GEORGE G. KENNEDY, *Readville, Mass.*
PROFESSOR L. M. UNDERWOOD, *Columbia University.*

CURRENT LITERATURE.

BOOK REVIEWS.

How to know the ferns.[1]

THE author of "How to know the wild flowers" (then Mrs. William Starr Dana) has already proved a charming guide to many lovers of nature. To introduce the same large class, in the same way, to such attractive plant forms as the ferns should bring to the author renewed expressions of gratitude. She writes of "ferns as a hobby," "when and where to find ferns," "fertilization, development, and fructification of ferns," and then begins her "fern descriptions." Fifty-seven species are selected for description and illustrations. The descriptions are not technical, and the general accounts of haunts and habits, and the literary allusions are just what one would expect from the author.

The artists should receive more than a passing commendation of their work, for not only is it truthful, but the graceful forms have lent themselves to most artistic treatment.

It is a pleasure to meet a book, designed for popular use, so well written and illustrated. If "How to know the ferns" does not induce many who are not botanists to take "ferns as a hobby" we are mistaken in our judgment.—J. M. C.

Lowson's text-book of botany.[2]

THIS book has certain limitations which must have interfered with the author's freedom. It is especially adapted "for the London University, Intermediate Science, and Preliminary Scientific Examinations." Taking merely the statement of facts, the author is clear and modern, presenting many things refreshingly in advance of the text-books, and current only in the university lectures of men who are at work.

Just where the author's responsibility ends and the demands of the formidable structure for which the book is adapted begin is not easy to tell, but we imagine that the line of division is crossed when one encounters the overwhelming verbiage of ancient morphology and taxonomy, so dear to English texts.

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[1] PARSONS, FRANCES THEODORA.—How to know the ferns; a guide to the names, haunts, and habits of our common ferns. Illustrated by Marion Satterlee and Alice Josephine Smith. 8vo. pp. xiv+215. New York: Charles Scribner's Sons. 1899.

[2] LOWSON, J. M.—A text-book on botany. The University tutorial series. 8vo. pp. viii+394. London: W. B. Clive. New York: Hinds & Noble (Cooper Institute). No date of publication; date of preface October 1898.

From the standpoint of logical presentation the book is a curiosity. The first part is general, discussing "external morphology, physiology, and general histology" in a way that compels the author to say, "it is not expected that the student will be able to master the contents of the opening chapters at the first reading." The second part deals with "the angiosperm" in rather a detailed way, and, of course, it is in connection with this topic that the glossary style of presentation appears. The third part deals with "vascular cryptogams and flowering plants." Thus, after the angiosperms are presented the ferns are taken up, then the equisetums, club mosses, and gymnosperms. Only at this point can the real homologies of angiosperm structure be indicated. The fourth and last part deals with "the lower cryptogams," and one advances from liverworts to mosses, and then backs down to algæ and fungi. This curious zigzag course does not have the excuse that the more recondite homologies are not being considered, for they are. The actual material in the book could be arranged into an orderly presentation of the evolution of the plant kingdom.

The book is an excellent compendium of facts for reference or topical reading, and probably indicates that the examinations provided for demand facts rather than principles. The illustrations are not of the first order, either in the original drawing, or in the reproduction. There is no longer any need for crude and harsh figures, even in elementary texts.—J. M. C.

The Schwendener Festschrift.

In honor of the seventieth birthday of Professor Dr. Simon Schwendener, of the University of Berlin, twenty-four of his pupils have prepared a *Festschrift* by publishing together a series of papers under the title *Botanische Untersuchungen.*[3] A fine photogravure of Schwendener forms a frontispiece of the volume.

Had Schwendener done nothing but inspire so energetic a group of investigators as are represented in these pages he would have done a great work for the advancement of knowledge. But the recent publication of his own collected papers has shown the great source of the inspiration which these pupils received, namely his own vigorous research. Surely three such volumes as these will at once fittingly commemorate and exemplify the life work of a great teacher.

It is impossible to discuss in detail the contributions which make up this

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[3] Botanische Untersuchungen, S. Schwendener zum 10. Februar, 1899, dargebracht. 8vo. pp. viii+470. *figs. 45. pl. 14*, and portrait. Berlin: Gebrüder Borntræger. 1899. *M* 25.

CURRENT LITERATURE.

BOOK REVIEWS.

How to know the ferns.[1]

THE author of "How to know the wild flowers" (then Mrs. William Starr Dana) has already proved a charming guide to many lovers of nature. To introduce the same large class, in the same way, to such attractive plant forms as the ferns should bring to the author renewed expressions of gratitude. She writes of "ferns as a hobby," "when and where to find ferns," "fertilization, development, and fructification of ferns," and then begins her "fern descriptions." Fifty-seven species are selected for description and illustrations. The descriptions are not technical, and the general accounts of haunts and habits, and the literary allusions are just what one would expect from the author.

The artists should receive more than a passing commendation of their work, for not only is it truthful, but the graceful forms have lent themselves to most artistic treatment.

It is a pleasure to meet a book, designed for popular use, so well written and illustrated. If "How to know the ferns" does not induce many who are not botanists to take "ferns as a hobby" we are mistaken in our judgment.—J. M. C.

Lowson's text-book of botany.[2]

THIS book has certain limitations which must have interfered with the author's freedom. It is especially adapted "for the London University, Intermediate Science, and Preliminary Scientific Examinations." Taking merely the statement of facts, the author is clear and modern, presenting many things refreshingly in advance of the text-books, and current only in the university lectures of men who are at work.

Just where the author's responsibility ends and the demands of the formidable structure for which the book is adapted begin is not easy to tell, but we anatomy cf hypocotyl and epicotyl in woody plants," reaches the conclusion that "the two regions are, in their primary structure, essentially dissimilar." Eight double plates illustrate the two papers.— J. M. C.

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[1] PARSONS, FRANCES THEODORA.—How to know the ferns; a guide to the names, haunts, and habits of our common ferns. Illustrated by Marion Satterlee and Alice Josephine Smith. 8vo. pp. xiv+215. New York: Charles Scribner's Sons. 1899.

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HEDWIG and Schwägrichen's type specimens from North America have been examined thoroughly and critically by M. Jules Cardot, who publishes, in the *Bulletin de l'Herbier Bossier* 7: 300. 1899, the first installment of his revision. One hundred and fifteen species have been investigated as fully as the frequent scantiness of the material would permit, of which sixty-one are discussed in this first section. Four plates provide important structural details which are wanting in the figures of Hedwig and Schwägrichen. The author remarks, by way of introduction, "I offer my work especially to my American *confrères*, who are engaged with so much zeal and talent in studying the bryological riches of their vast continent. I hope that they will receive it kindly, and I shall be amply repaid for my labor if they consider it of some utility." We may say that, without question, M. Cardot has made American bryologists his debtors, for the work is one that will be of great service to them and certainly merits their grateful thanks.— C. R. B.

MR. EDWARD C. JEFFREY[5] has been studying Equisetum and its allies, chiefly as to the development of tissues and organs. Two primitive types of stelar structure are distinguished, the single concentric strand and the tubular concentric strand. The former he calls protostelic, the more primitive type; the latter siphonostelic. The siphonostelic type has two modifications, which he calls phyllosiphonic and cladosiphonic. In the former case the continuity of the vascular cylinder is interrupted by lacunæ occurring above the points of exit of the leaf traces; in the latter case the lacunæ occur above the traces of the branches. Phyllosiphony is associated with large leaves, as in Filicales, cladosiphony with small leaves, as in Equisetales and Lycopodiales. In reference to the morphology of the vascular strands the author returns to the standpoint of Sachs and De Bary, as opposed to that of Van Tieghem modified by Strasburger.

He also finds that in the development of the archegonium there is no basal cell, as in the homosporous Filicales, and that the neck canal cell divides longitudinally, as reported by Treub for *Lycopodium phlegmaria*.

In tracing the development of the sporophyte embryo Mr. Jeffrey finds that both root and shoot arise from the epibasal region, a fact not at all in accord with the embryogeny of homosporous Filicales.

The conclusion is reached that the Equisetales are related to the Lycopodiales rather than to the Filicales, the points of resemblance and distinction being as follows: gametophyte with fleshy vertical axis and thin lateral lobes, archegonium with no basal cell and with vertical division of the neck canal cell, root and shoot epibasal in origin, small leaves and strobili, and cladosiphony.

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[5] The development, structure, and affinities of the genus Equisetum. Memoirs Boston Soc. Nat. Hist. 5: 155–190. *pls. 26–30.* 1899.

Fossil forms were also considered, and, applying the data mentioned above, it was concluded that the Sphenophyllum forms should not constitute a separate phylum, but that they belong to the Equisetum series, as primitive protostelic forms. Accordingly the phylum Equisetales, extending from the Silurian to the present time, is made to include three families, Sphenophyllaceæ, Calamitaceæ, and Equisetaceæ.—J. M. C.

M. W. BEIJERINCK[6] has made a valuable contribution to the subject of spore production in alcoholic yeasts. The method employed by him, which I have tried also and found successful, was as follows:

Two per cent. agar-agar was added to distilled water and boiled until thoroughly dissolved, then filtered and poured in a thin layer into a shallow glass dish. This is allowed to cool and solidify and is cut into thin strips, which are placed in a flask containing distilled water. The water is changed about once a week; in this way the agar is washed and purified and we obtain what Beijerinck terms "pure" agar. After the agar has been treated for a period of about six weeks, it is transferred into a clean flask and dissolved in the steam-bath, then placed in test tubes and sterilized in the usual manner.

The yeast is then spread in a very thin layer over the surface of slanted agar and the whole placed in the incubator at 28–30°C. or kept at the room temperature. Beijerinck obtained his best results by using room temperature, but I have obtained the best results with ordinary beer yeast at a temperature of 28–30°C.

Beijerinck also found that a sporogenous yeast cell multiplies by forming spores, and that if the cell begins to multiply by budding it cannot again be brought to produce spores.

In addition to the method for producing spores in yeast, Beijerinck in the second part of his paper gives some characteristics by means of which the sporogenous yeast cells can be distinguished microscopically from the asporogenous; they are as follows:

1. Spore-bearing cells can be differentiated from spore-free cells by means of the iodine reaction, inasmuch as in some cases the spores contain granules in the wall which stain blue, while the cell capsule remains colorless; in other cases the cell capsule contains glycogen and stains violet-brown by iodine, while the cell contents remain unstained (*S. Uvarum*), or finally the sporulation may be characterized through an accumulation of glycogen

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[6] BEIJERINCK, M. W.: Ueber Regeneration der Sporenbildung bei Alkoholhefen, wo diese Funktion im Verchwinden begriffen ist. Centr. f. Bakter. Parasit. u. Infek. **42**: 657–663, 721–730.

in the cell capsule and spores, which accordingly stain with iodine while the asporogenous cells are glycogen free (*S.* [*Mycoderma*] *orientalis*) and do not stain by iodine.

2. Spore-bearing colonies liquefy gelatin usually much faster than spore-free colonies.

3. Colonies with spores are often snow-white, while the spore-free colonies are colored watery-brown.—H. E. DAVIES.

THE KARYOKINETIC division of the nucleus of *Allium Cepa* has been further investigated by Nêmec.[7] In studying the formation of the achromatic spindle he finds that it does not begin as a multipolar affair, as found in other plants by Mottier, Osterhout, and others, but is bipolar from the beginning of its formation. Threads which appear just outside the nuclear membrane are soon seen to be drawn out into poles at opposite sides of the nucleus. The spindle fibers of either pole may be of unequal length, but all converge toward a common point. Some of the figures suggest that other interpreters might claim for them the condition of multipolarity. The nuclear membrane does not often disappear until the achromatic spindle is almost formed, and there is no evidence justifying the statement that it contributes to the formation of the spindle. The form of the spindle is determined by the dimensions of the dividing cell. The development of spindles in cells of the plerome shows characteristic differences from the same process in cells of the periblem.

At about the time the nuclear membrane disappears the chromatin thread breaks up into a few divisions, and these again break up forming the chromosomes. If the chromosomes are short they are placed parallel to the spindle threads, while if they are long there is no regularity in their position. Some spindle fibers pass directly from pole to pole, while others are attached to the chromosomes. The chromosomes split longitudinally, beginning at the looped end. After the pairs of chromosomes have divided somewhat, fibers are seen connecting them, and Nêmec states that these fibers are entirely different in structure from those which first formed the spindle. They are thicker, more granular, and stain more like chromatin than the earlier formed fibers. As to their function, he says any statement would at present be a mere guess, but suggests that, by exerting a push, they may assist the fibers which are pulling the chromosomes.

Structures which have been described by some other writers as centrosomes are represented in the drawings, but the author thinks they are nucleoli, and are finally enclosed within the nuclear membrane.

The statement is made that the chief morphological difference between the division of cells of vegetative tissue and those of sporogenous tissue consists in the fact that the spindle of division of the former is always bipolar, while that of the latter may be multipolar at the beginning, and may or may not become bipolar.

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[7] Ueber die karyokinetische Kerntheilung in der Wurzelspitze von *Allium cepa*. Jahrb. f. wiss. Bot. **33**: 313–336. 1899.

Throughout the paper few references are made to the work done by others along these same lines. While the work is very similar to (and in some cases a repetition of) that done by Schaffner on *Allium Cepa* and published by him in the latter part of last year, no reference is made to it.—OTIS W. CALDWELL.

THE RECENT note by Nawaschin[8] on the peculiar behavior of the male cells in *Lilium Martagon* has called out a more extended paper by Guignard[9] upon the same subject. The preliminary statements of Nawaschin are confirmed, and the presentation of good figures adds to the conclusiveness of the demonstration.

Of the two male nuclei, one fuses with that of the egg, while the other, probably the first one to leave the pollen tube, passes on to fuse with one of the polar nuclei. This union is generally with the upper polar, but if the lower one happens to be more conveniently situated the male nucleus will be attracted to it. Hence the process cannot be explained by the fact that the two equivalent male nuclei are attracted respectively by the oosphere nucleus and its sister, the upper polar. In either case the ultimate fusion of all three nuclei is recorded.

A case figured in which the male nucleus, coiled like a closely compressed letter S, lies in the angle between the fusing polars, is cited as presenting a condition which, with the less perfect technique of eight years ago, might have been taken for a pair of fusing centrosomes. Possibly some will not see clearly how such a body could be cut so as to show the *two* pairs of fusing centers on opposite sides of the polar nuclei, as they have been figured in the familiar "quadrille." The new figures leave us still in the dark upon this point.

The fusion nucleus, whether of oospore or endosperm, preserves the external marks of its dual or triple nature, even in prophase stages. Under such conditions as have been described, the increased number of chromosomes in endosperm nuclei may find an easy explanation.

The male nuclei are described as long and variously twisted bodies, many of them presenting appearances which, as noted by Nawaschin, suggest a possible motility. While they are devoid of cilia and cytoplasm, they nevertheless deserve to be called antherozoids.

It may be of interest to call attention to somewhat similar observations made by other botanists. Golinski[10] reports male cells in pollen grains and tubes of Triticum and other grasses, which "are not unlike the antherozoids of a fern or of Chara." His figures, however, are very unsatisfactory. Mottier[11] figures a coiled male nucleus closely applied to the female, in *Lilium Martagon*. Indications of a male nucleus fusing with the polars have been found in *Lilium Philadelphicum* by some students in the Hull Botanical Laboratory during this last year. The present writer has found elongated, and often spirally twisted male cells in the pollen of Silphium, the figures for which are soon to be published. It would seem, then, that such reminiscent forms of male cells are to be looked for almost anywhere, if they can be found in such widely separated groups as the Gramineæ, Liliaceæ, and Compositæ.—W. D. MERRELL.

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[8] Bot. Cent. 77: 62. 1899.

[9] Sur les anthérozoïdes et la double copulation sexuelle chez les végétaux angiospermes. Comptes Rendus **128**: 1–8. Apr. 1899.

OVERTON'S STUDIES on color have been previously referred to in this journal.[12] His results have now been more fully published and furnish some interesting data.[13] The author noticed that a red coloration appeared in leaves of Hydrocharis grown in a sugar solution, and that the colors deepened as the solution became more concentrated by evaporation. Knowing also that alpine plants are more highly colored than plants in the lowlands and that low temperatures cause an increase of sugar at the expense of starch, Overton felt that it was worth while to make some experimental studies as to the connection between red cell sap and sugar.

Elaborate and varied experiments were made on Hydrocharis. In water cultures the colors were developed by increasing the light sufficiently or decreasing the heat, light and heat being opposing factors. Where the light and heat conditions were such as to produce no red coloration in water cultures, 2 per cent. invert sugar solutions induced colors within three days. Both old and new leaves are affected and the colors deepen day by day. Plants grown in sugar solutions bloom sooner than when grown in water. Experiments with various other sugars resulted similarly. The color stuff is mainly in the palisades and may be precipitated by coffein or antipyrin in a form resembling precipitates of tannin stuffs. Utricularia, Elodea, Trapa, and other water plants gave similar results. Experiments were also made on cut stems of Lilium, Ilex, and other land plants; colors were obtained in sugar solutions but not in water cultures.

The author concludes that the formation of red cell sap is closely connected, in most of the plants studied, with a rich content in sugar. Low temperatures, but considerably above the freezing point, induce red coloration. Alpine leaves are more highly colored than leaves from the lowlands because of low night temperatures and increased light intensity. The red coloration in many winter leaves is due to an increase of sugar at the expense of starch, a condition that is brought about by low temperatures. Cultivation in sugar solutions as a rule produced coloration only in those plants in which colored cell sap, when present, occurs in the mesophyll. Plants that have red sap in the epidermis failed to respond to sugar solutions. The reddening of many fruits and the deeper coloration of alpine flowers may be due to the change of starch to sugar.

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[10] Bot. Cent. **55**: 1–17, 65–72, 129–135. 1893.

[11] Jahrb. f. wiss. Bot. **31**: 125–158. 1898.

[12] BOT. GAZ. **27**: 229. 1899.

[13] Beobachtungen und Versuche über das Auftreten von rothem Zellsaft bei Pflanzen. Jahrb. f. wiss. Bot. **33**: 171–231. 1899.

Overton thinks that the red pigment is a glucoside or some nearly related compound. The cells which contain the colored cell sap often have tannins present, whereas in many plants that showed no coloration there is no tannin. The precipitates thrown down by coffein and antipyrin resemble those of the tannins, and the author concludes that one of the constituents of the red pigment is a tannic acid. The chemical nature of the pigment doubtless varies considerably in different plant groups.

The paper closes with a review of studies on red cell sap, giving great credit to the pioneer work of von Mohl. Wigand long ago associated the red color with tannins. Although Overton says little as to the ecological significance of red colors, he inclines to Stahl's view that they increase the available heat of the plant and thus favor nutrition. He thinks it possible that red colors may have been produced as an adaptation to unfavorable conditions by means of natural selection.—H. C. COWLES.

ITEMS OF TAXONOMIC interest are as follows: F. KRÄNZLIN has completed (Engler's *Bot. Jahrb.* **26**: 449–502. 1899) his account of Lehmann's Orchidaceæ from Central and South America, in this last fascicle describing about seventy-five new species and three new genera (*Otopetalum*, *Neolehmannia*, *Pterostemma*).—F. PAX (*ibid.* 503–508) has published Lehmann's South American Euphorbiaceæ, describing nine new species.—A. ENGLER (*ibid.* 509–572) has published his ninth installment of revisions of the genera of Araceæ, which contains *Philodendron* with 167 species, twenty-six of which are new, and *Dieffenbachia*, with eighteen species, one being new.—F. BUCHENAU discusses Ule's Brazilian Juncaceæ (*ibid.* 573–579), and also the genus Tropæolum (*ibid.* 580–588).—P. DIETEL and F. W. HEGER (*ibid.* **27**: 1–16. 1899) have published their third paper on Chilean Uredinaceæ, proposing *Mikronegeria* as a new genus.—R. PILGER (*ibid.* 17–36) in publishing Lehmann's and Stübel's South American Gramineæ describe numerous new species.—A. ENGLER'S studies of the African flora have reached the eighteenth number (*ibid.* 37–237), which contains the following contributions: G. LOPRIORE, on Amarantaceæ, in which twenty-two new species are described, a new genus *Sercostachys* proposed, and *Sericorema* and *Cypho-*

carpa, both heretofore sections of Sericocoma, raised to generic rank; W. RUHLAND on *Eriocaulon*, in which thirty-nine species are recognized, sixteen of which are new; R. SCHLECHTER on new and little known plants of his own collecting, being a second fascicle, and containing descriptions of 195 new species, one of which is the type of a new genus of Papaveraceæ, called *Trigonocapnos*.—W. A. SETCHELL (*Erythea* 7:45–55. 1899) continues his notes on Cyanophyceæ, describing two new species of *Scytonema* and one of *Nostoc*.—P. A. RYDBERG (*Bull. N. Y. Bot. Garden* 1:257–278. 1899) has published an account of the cespitose willows of arctic America and the Rocky mountains, including thirty-three species, ten of which are new.—J. K. SMALL (*ibid.* 278–290), in continuing his studies upon the flora of southern United States, has described seventeen new species in miscellaneous genera.—GEO. V. NASH (*ibid.* 290–294) has just described five new southern grasses.—M. L. FERNALD (*Proc. Am. Acad.* 34:485–503. 1899) has been studying *Eleocharis ovata* and *Scirpus Eriophorum*, and discovers considerable confusion and massing of forms. What has gone under the former name, a European species, proves to be for the most part distinctly American, and is *E. obtusa* Schultes. True *E. ovata* R. Br. also occurs at a few stations; while out of the plexus of forms three new species (*E. lanceolata*, *E. monticola*, *E. Macounii*) and four new varieties are disentangled, besides three already described species and one variety. In the case of *Scirpus Eriophorum* Mx. two new varieties are described, and a new species (*S. atrocinctus*) and variety separated.—L. M. UNDERWOOD (*Bull. Torr. Bot. Club* **26**:205–216. 1899), in his second paper on American ferns, discusses the genus *Phanerophlebia* Presl. which contains the form commonly called *Aspidium juglandifolium*, recognizing eight species, four of which are new.—E. P. BICKNELL (*ibid.* 217–231) has begun a study of *Sisyrinchium*, this first paper containing descriptions of sixteen new species from the southern states.—B. L. ROBINSON (*ibid.* 232–235) has published a revision of *Guardiola*, recognizing nine species, five of which are either new or are raised to specific rank.—AVEN NELSON (*ibid.* 236–250) continues his descriptions of new plants from Wyoming, the present fascicle containing twenty-two new species, two of which are included in a new genus (*Wyomingia*) founded on *Erigeron pulcherrimus* Heller.—J. M. C.

BEFORE THE Royal Society (London), Professor H. Marshall Ward recently read a paper upon *Onygena equina* Willd., a horn-destroying fungus. The following is an abstract by the author:

The genus *Onygena* comprises half a dozen species of fungi, all very imperfectly known, remarkable for their growth on feathers, hair, horn, hoofs, etc., on which their sporocarps appear as drumstick shaped bodies 5–10^{mm} high. A cow's horn, thoroughly infested with the mycelium of the present species, yielded material for the investigation, and the author has not only verified what little was known, but has been able to cultivate the fungus and trace its life history, neither of which had been done before, and to supply some details of its action on the horn.

The principal new points concern the development of the sporophores, which arise as domed or club-shaped masses of hyphæ and stand up into the air covered with a glistening white powder. Closer investigation shows this to consist of chlamydospores, formed at the free ends of the up-growing hyphæ. Their details of structure and development are fully described, and their spore nature proved by culture in hanging drops. The germination, growth into mycelia, and peculiar biology of these hitherto unknown spores were followed in detail, and in some cases new crops of chlamydospores obtained direct in the cultures.

When the crop of chlamydospores on the outside of the young sporophore is exhausted, the hyphæ which bore the spores fuse to form the peridium clothing the head of the sporocarp, and peculiar changes begin in the internal hyphæ below.

Minute tufts or knots of claw-like filaments spring from the hyphæ forming the main mass of the fungus, push their way in between the latter, and so find room in the mesh-like cavities. Here the closely segmented claws form asci — they are the ascogenous hyphæ — and the details of development of the asci, their nucleated contents, and the spores are determined. As the spores ripen, the asci, which are extremely evanescent, disappear, and in the ripe sporocarp only spores can be seen lying loose in the meshes of the gleba. The ascomycetous character of the fungus is thus put beyond question, though the peculiar behavior of the developing ascogenous tufts at one time rendered it questionable whether the older views as to the relationships were not more probable.

No one had hitherto been able to trace the germination of these ascospores — the only spores known previously — and De Bary expressly stated his failure to do it. The author finds that they require digesting in gastric juice, and so in nature they have to pass through the stomach of the animal. By using artificial gastric juice, and employing glue and other products of hydrolysis of horn, the details of germination and growth into mycelia, capable of infecting horn, were traced step by step under the microscope and fully described.

No trace of any morphological structure comparable to sexual organs could be discovered, though many points suggest the alliance of this fungus with Erysipheæ and truffles.

The author also found that similar digestion promotes the germination of the chlamydospores, and in both cases has not only traced the germination step by step, but has made measurements of the growth of the mycelium, induced the formation of chlamydospores on the mycelium again, and by transferring vigorous young mycelia to thin shavings of horn has observed the infection of the latter.

It thus becomes evident that the spores of *Onygena* pass through the body of an animal in nature, and, as might be expected from this, extract of the animal's dung affords a suitable food medium to re-start the growth on horn. Probably the cattle lick the *Onygena* spores from their own or each other's hides, hoofs, horns, etc., and this may explain why the fungus is so rarely observed on the living animal: it is recorded from such in at least one case, however.

Very little is known as to the constitution of horn, and some experiments have been made to try to determine what changes the fungus brings about. The research has also obvious bearings on the question of the decomposition of hair, horn, feathers, hoofs, etc., used as manure in agriculture. Although a bacterial decomposition of hoof substance is known to the author, special investigation of the question showed that in the present case no symbiosis between bacteria and the *Onygena* exists.

For the details as to the literature, the discussion as to the systematic position of *Onygena*, the experimental cultures, growth measures, and the histology, the reader is referred to the full paper, which is illustrated by plates and numerous drawings.— H. M. WARD.

NEWS.

DR. W. NYLANDER, the Nestor of lichenologists, died in Paris on March 29, in his seventy-eighth year.

MESSRS. HAROLD LYON and W. H. Wheeler have been appointed assistants in botany in the University of Minnesota.

MR. JOHN LOUIS SHELDON has been appointed assistant in botany, to give instruction in the School of Agriculture of the University of Nebraska.

OTTO BÖCKELER, a pharmacist of Varel, Oldenburg, known for his systematic studies on the genus Carex, died on March 5, at the great age of 95.

MR. ALBERT T. BELL, of the University of Nebraska, will visit the Republican valley in the course of the summer, with a special view to collecting Uredineæ.

DR. RODNEY H. TRUE has resigned the assistant professorship of pharmacognosy at the University of Wisconsin. He expects to spend the next year in reading and research at Harvard University.

DR. CHARLES E. BESSEY, of the University of Nebraska, will shortly visit the foothills of western Nebraska, collecting specimens and making phytogeographical notes in the region above 1200^{m} altitude.

PROFESSOR DR. GUNTHER BECK, Ritter von Mannagetta, has been appointed professor of botany, and director of the botanical garden of the German University of Prag, as successor to Dr. R. von Wettstein.

PROFESSOR JOHN MACOUN will be engaged during the summer in field work upon Sable island, "the graveyard of the Atlantic." Later in the season he will examine botanically some of the remote parts of New Brunswick.

MR. JARED G. SMITH, of the U. S. Department of Agriculture, has been transferred from the Division of Agrostology, and after June 30 will be associated with Mr. O. F. Cook in the Section of Seed and Plant Introduction of the Division of Botany.

DR. J. N. ROSE, of the U. S. National Museum, left Washington about May 1 for an absence of three months in central and southern Mexico. He will make a special study of the genus Agave, especially those species used in the making of pulque and mescal, and will visit the tequila plantations of western Jalisco. An investigation of the Tampico hemp industry will also be made. Of course a general botanical collection will be secured, and a list of the type localities of several hundred species, many of which are not represented in American herbaria, will give a very definite purpose to the collecting.

DR. F. E. CLEMENTS, after giving instruction in botany in the Summer School of the University of Nebraska from June 9 to July 20, will visit the Missouri river bluff region, making a careful study of the phytogeographical regions from Florence southward.

DR. B. M. DUGGAR, instructor in botany in Cornell University and assistant cryptogamic botanist in the Experimental Station, has leave of absence for the coming year, and is already working in the laboratories for plant physiology under Dr. Pfeffer in Leipzig, and in those for experimental morphology under Dr. Klebs at Halle.

WHAT HAS BEEN heretofore the Summer School of Cornell University, being a private or individual affair managed by the instructors directly concerned, has now become a regular six-weeks term of the university. Professor George F. Atkinson has been appointed for this year to give instruction in botany, with Mr. Heinrich Hasselbring as his assistant.

AT THE MEETING of the Academy of Science of St. Louis on May 1, 1899, Mr. H. von Schrenk presented the general results of a study of certain diseases of the yellow pine, illustrating his remarks by the exhibition of a number of specimens showing the characteristic phenomena of the diseases and the fruiting bodies of the fungi which caused them.—WM. TRELEASE.

AFTER EIGHT YEARS of service, Professor D. H. Campbell has been given leave of absence for a year from Leland Stanford University. He will sail for Europe about the middle of July. After spending some time in England, he will winter about the Mediterranean, going as far east as Egypt. His journey is chiefly for recreation, although he will do some botanical work.

THERE ARE in southern California three notable collections of cacti and other plants of arid regions that should be known to students and specialists. Two of these are in San Diego, one of them forming a part of the exceedingly interesting garden of Mr. and Mrs. T. S. Brandegee, the other belonging to Mr. Charles R. Orcutt. The third collection is the property of Mr. A. H. Alverson, of San Bernardino.—V. M. SPALDING.

MR. ROBERT COMBS died April 11, at the age of twenty-seven years. He was known to botanists through the publication of his collections in the vicinity of Cienfuegos, Cuba; and through his paper on the medical plants of Cuba. He was an assistant in botany in Iowa State College and the Agricultural Experiment Station, and at the time of his death was one of the field agents of the Division of Agrostology, Department of Agriculture.

THE STATE FORESTRY STATION, near Santa Monica, California, under the charge of Mr. C. A. Colmore, has an interesting collection of Eucalyptus, about sixty species being represented. The chief object of the station is to determine by actual experiment the adaptibility of different trees and shrubs to the climatic conditions of the region in which it is located, and to disseminate information on forestry and arbor-culture. With limited means the indefatigable superintendent is carrying on a most important work and one that suggests the great desirability of the multiplication of such stations throughout the United States.—V. M. SPALDING.

MR. E. H. HARRIMAN, a prominent railroad official, wishing to visit Alaska, has invited a party of scientific men to accompany him by special train and steamer. Among the party are several botanists: Dr. William Trelease, Director of the Missouri Botanical Garden; Mr. F. V. Coville, Chief of the Division of Botany of the U. S. Department of Agriculture; Prof. De Alton Saunders, of the University of South Dakota; and Mr. T. H. Kearney, of the New York Botanical Garden. Dr. B. E. Fernow, Dean of the College of Forestry, Cornell University, is also a member of the party. Mr. Saunders will give special attention to the marine algæ, Mr. Coville and Mr. Kearney to the vascular plants, and Mr. Trelease to fungi. The expedition left Chicago on May 25, and will return about August 1.

THE PACIFIC COAST LABORATORY at Santa Ana, California, established as a branch of the Division of Vegetable Physiology and Pathology of the U. S. Department of Agriculture, has accomplished within a few years a large amount of valuable work. In 1889 Mr. Newton B. Pierce was appointed a special agent to investigate the California vine disease, and, as a result of the study then undertaken, preventive measures have been recommended and so far adopted as to render recurrence of the disease, with its former wholesale destructiveness, practically impossible. Subsequently Phylloxera was discovered and stamped out in time to prevent its extensive spread, and investigations have for some time been in progress that give good promise of equally important results in the production of varieties of grapes immune to attacks of *coulure*, a disease that annually causes a loss of half a million dollars to the vineyardists of the San Joaquin valley. A large series of different sprays for the treatment of peach curl were first tested here, and methods for its control were first introduced into the different peach growing states from this station. The laboratory has an excellent equipment, including bacteriological outfit, photographic apparatus, an extensive collection of photographs illustrative of plant diseases of the Coast region, and a good working library. It has gradually grown into a bureau of information and advice for horticultural commissioners and practical horticulturists of the whole Pacific Coast.—V. M. SPALDING.

GENERAL INDEX.

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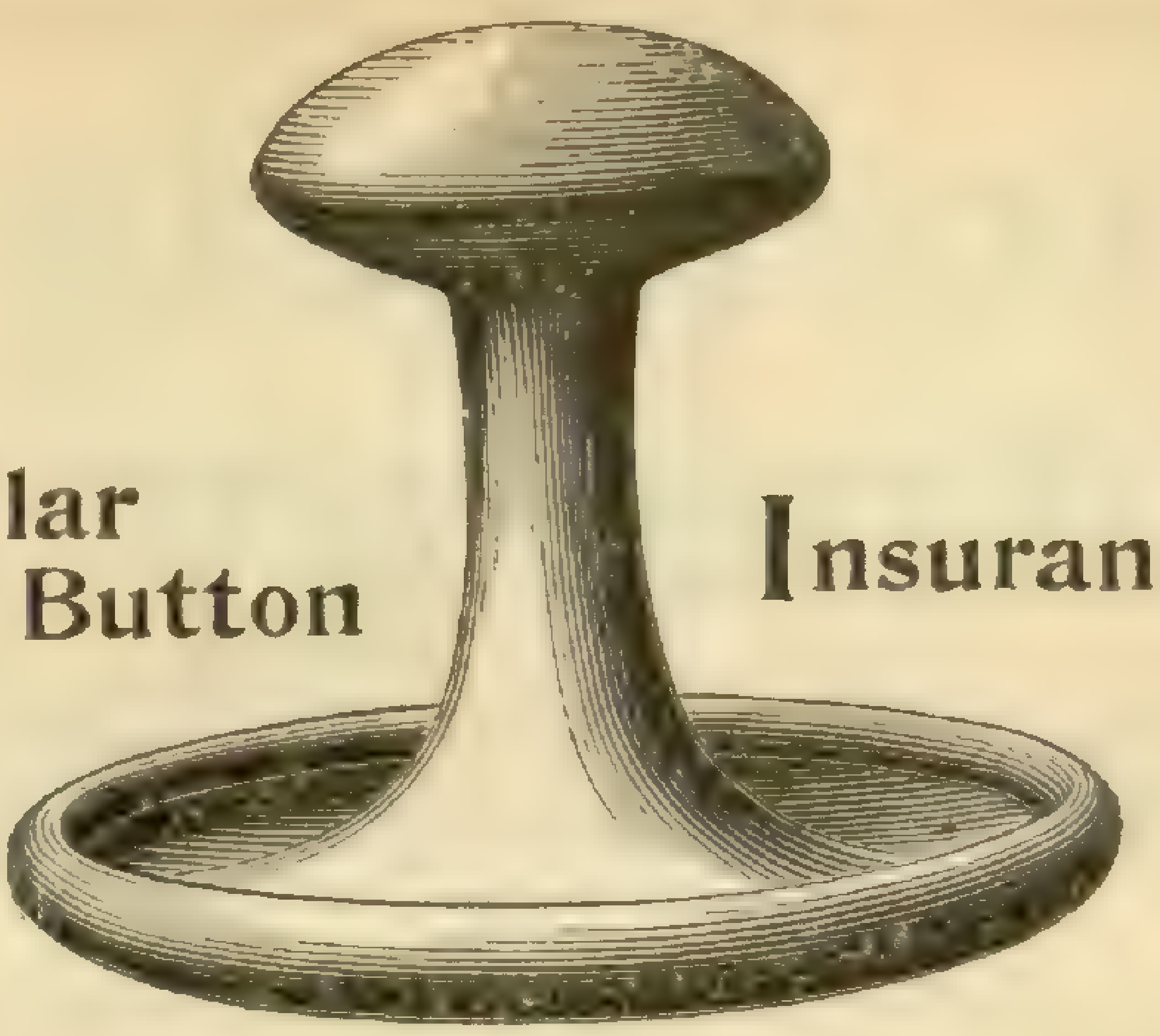

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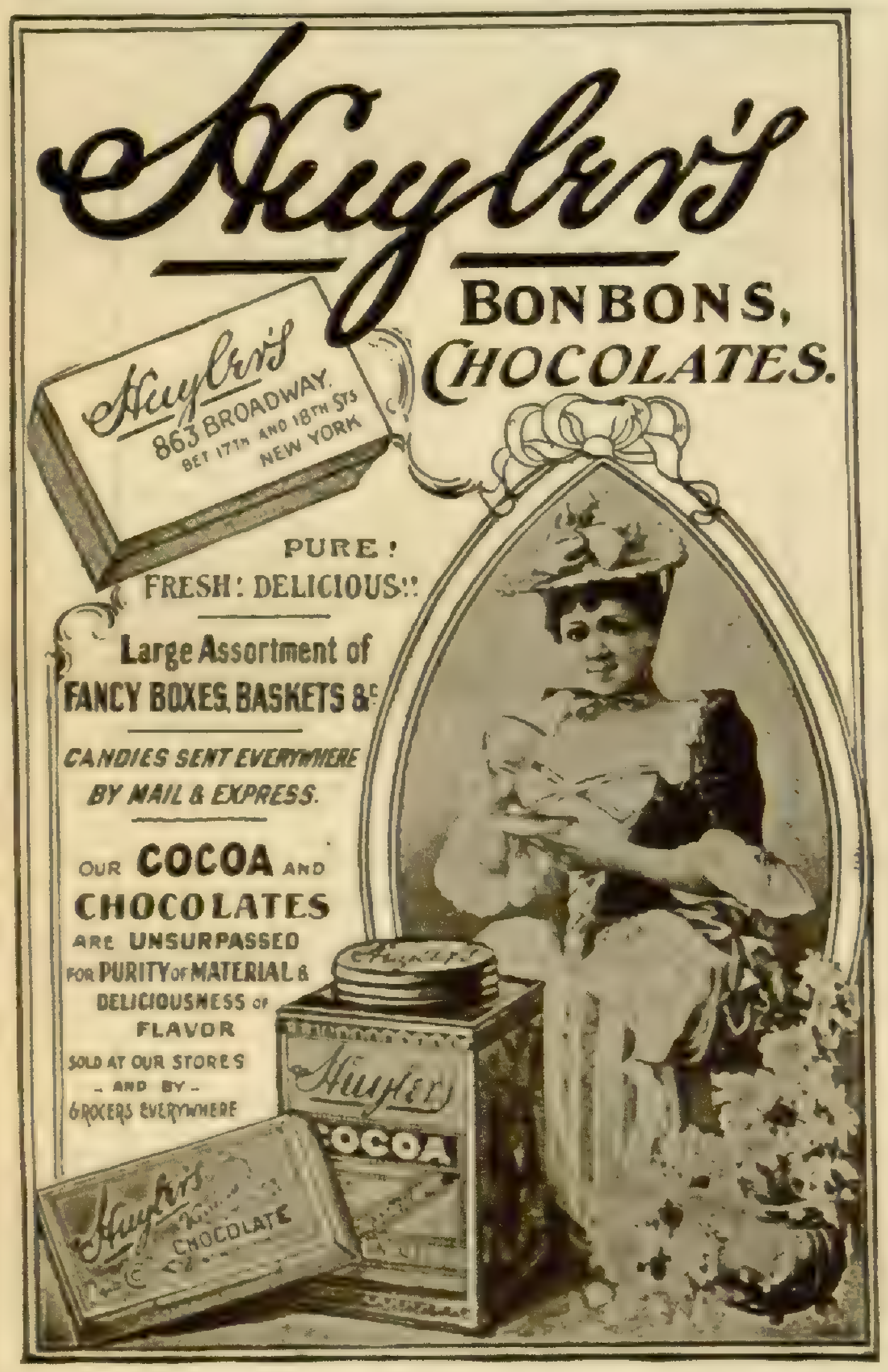

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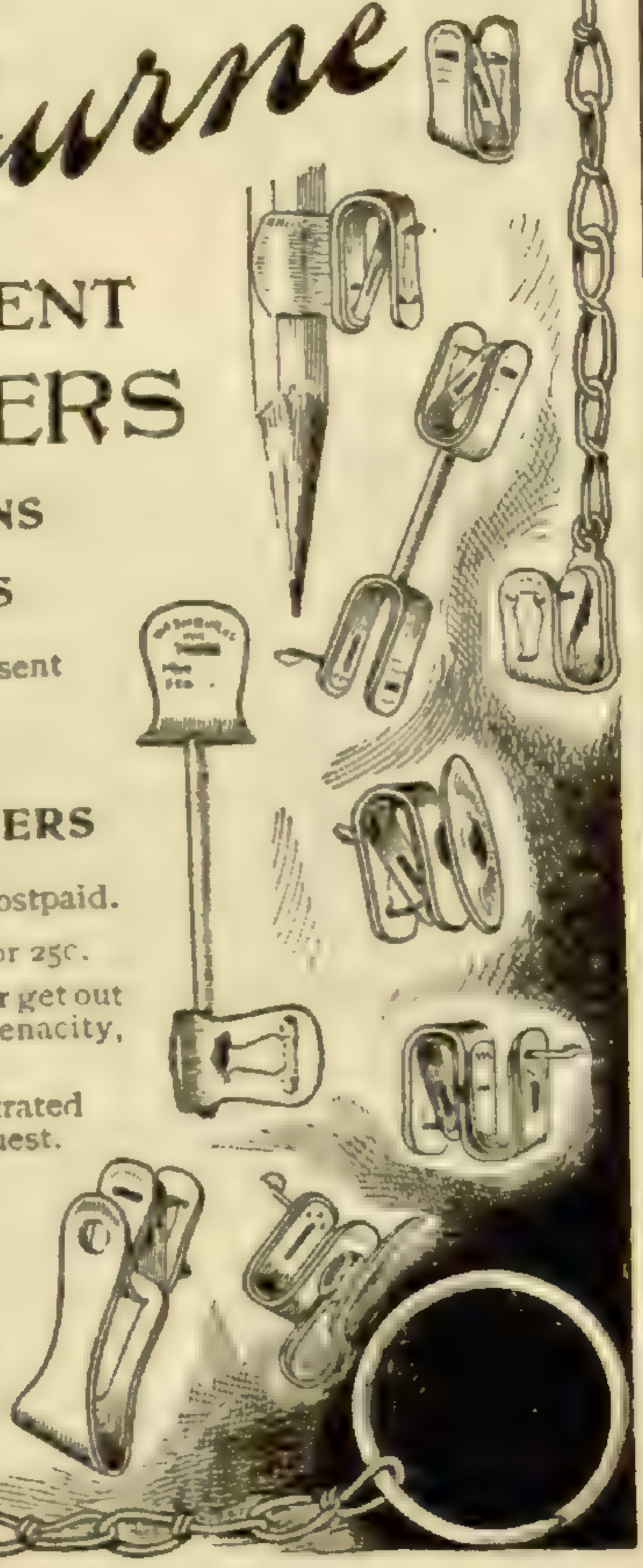

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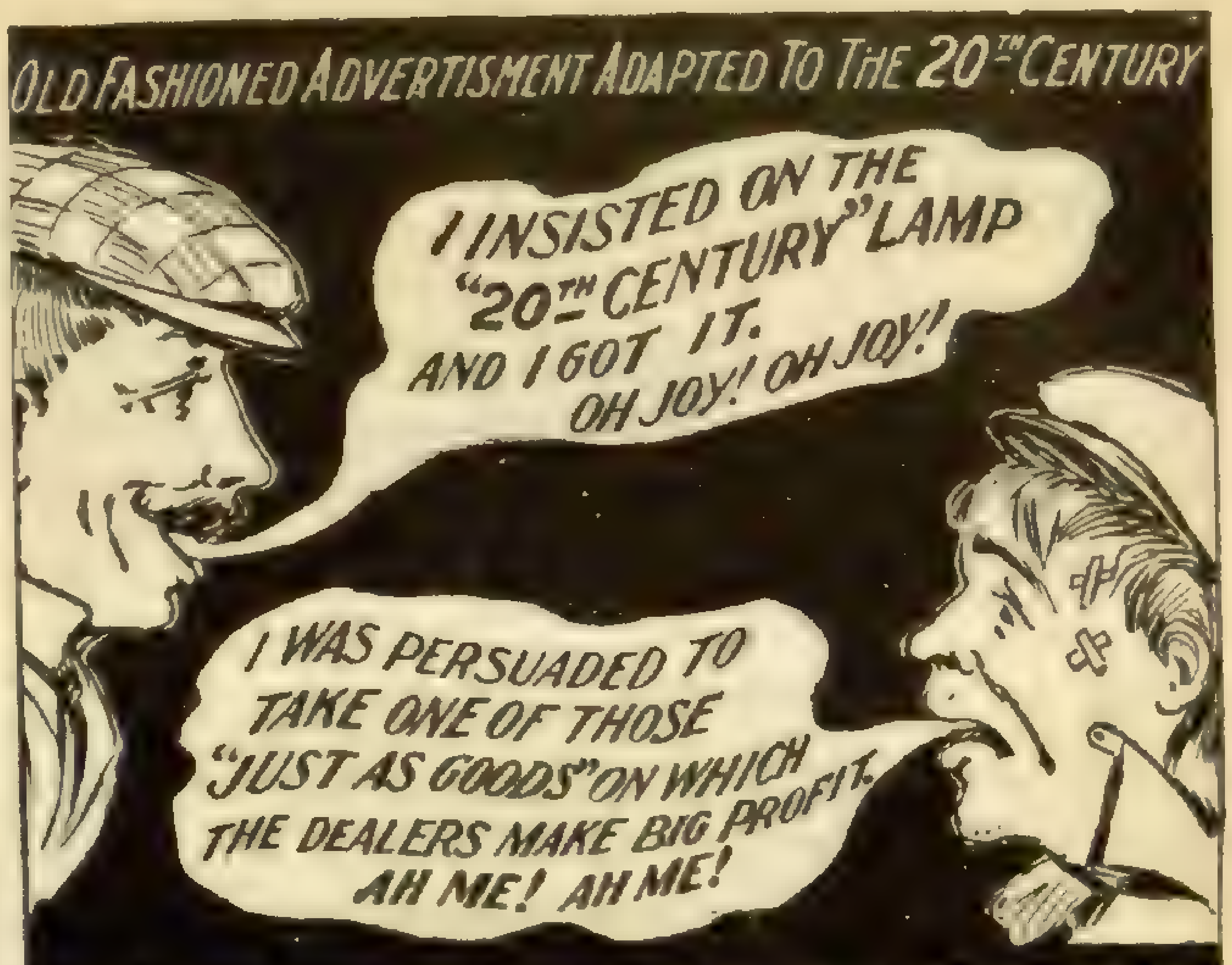

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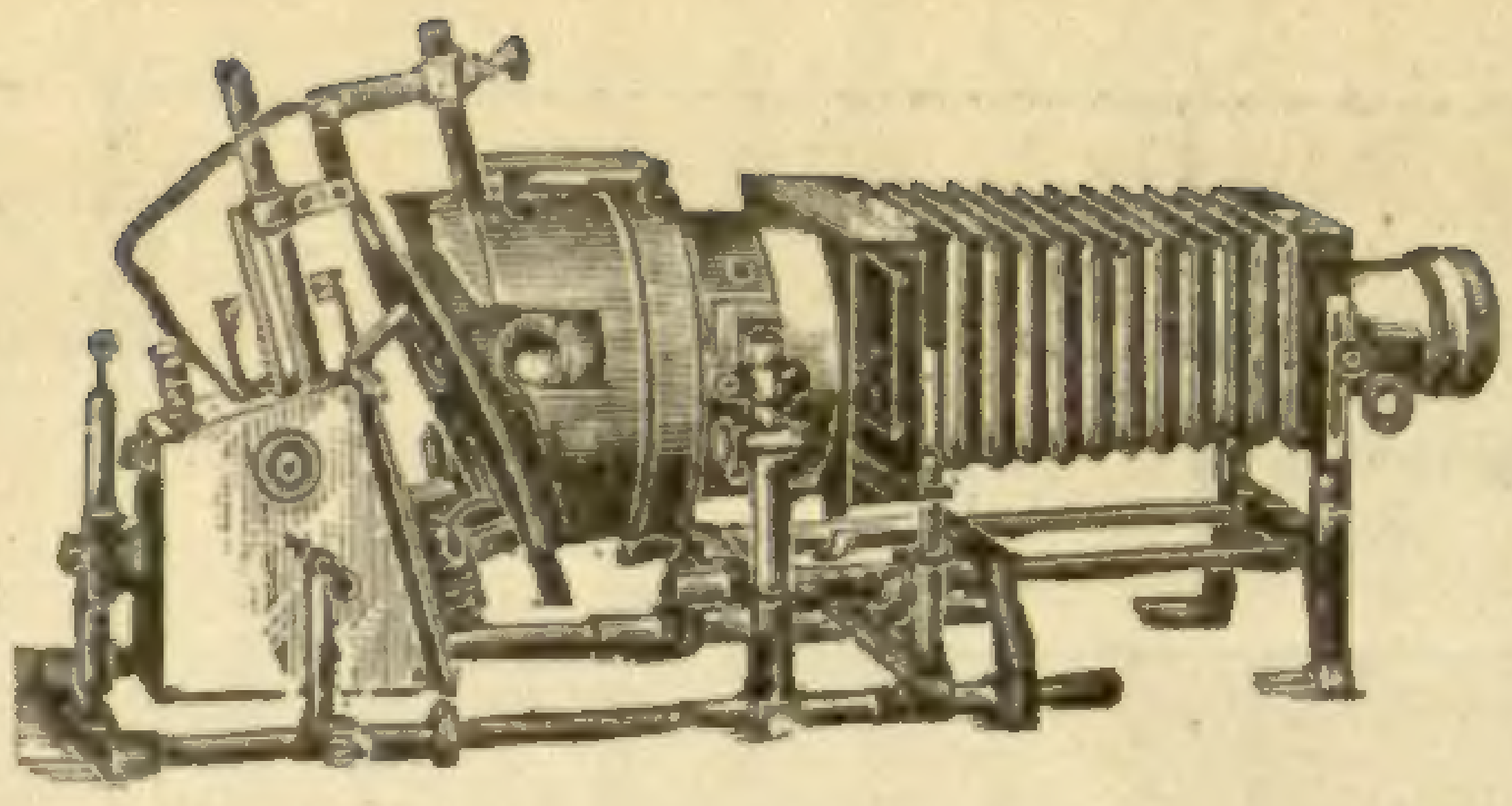

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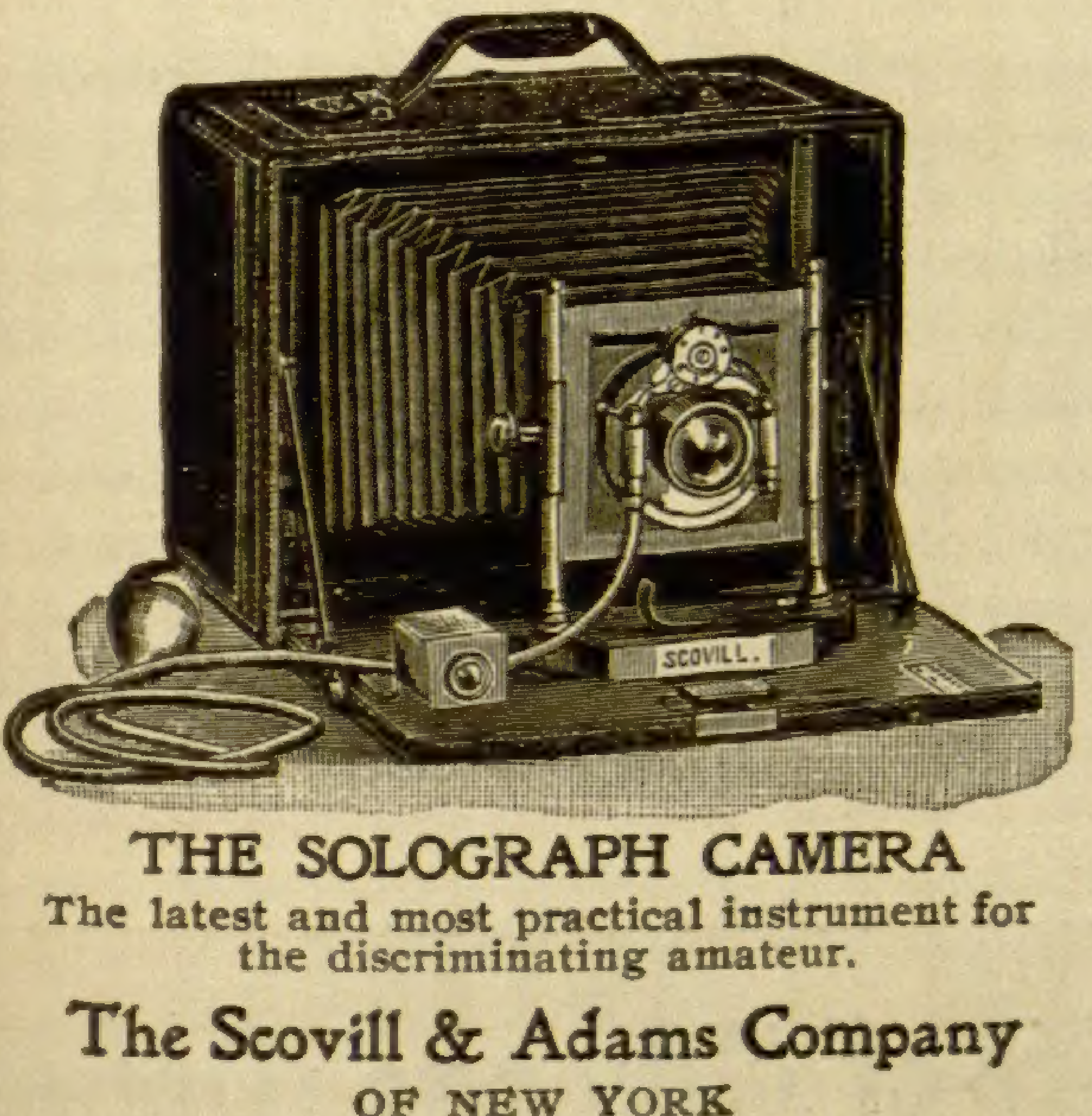

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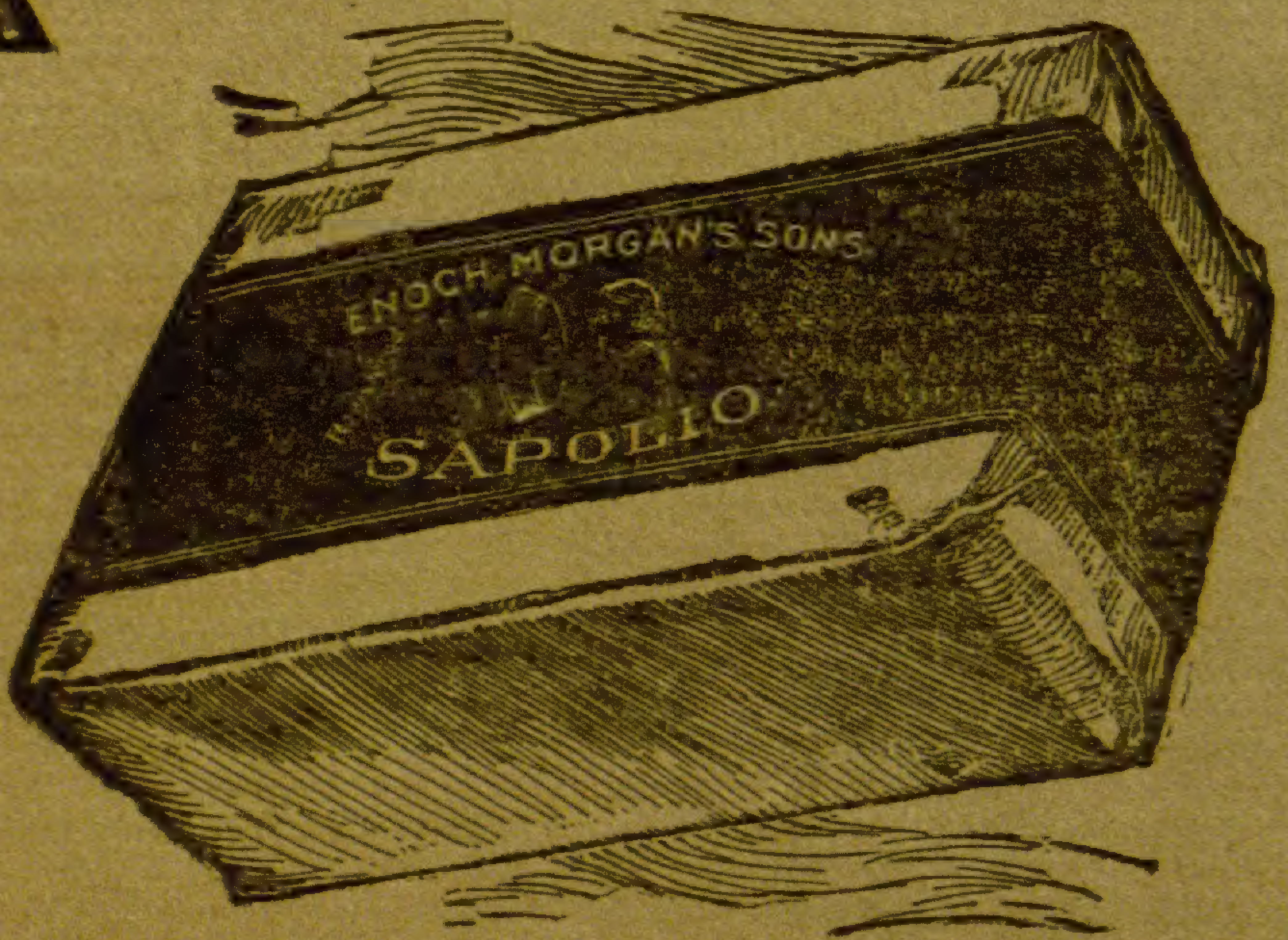

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